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PLATE V.—*THE CIRCULATION.*

TEXT-BOOK

OF

ANATOMY, PHYSIOLOGY,

AND

HYGIENE.

DESIGNED FOR USE IN COLLEGES, HIGH SCHOOLS, ACADEMIES AND FAMILIES.

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PREFACE.

At the present age of the world when Solomon's assertion that "of making many books there is no end" is more emphatically true than ever before, no apology can be offered for presenting to the public a new book on any subject unless the new production presents some advantages over its predecessors. This is as true of educational works of all classes as of other books. It seems to be the fashion at the present time for every professor in a college of any distinction to issue a text-book. This has been going on until the market is glutted with school books on all subjects. In some departments, as in mathematics, language, and most of the natural sciences, our text-books have attained a high degree of excellence; unfortunately, however, this cannot be said of the books furnished to students upon the subject presented in this work. For several years this fact has been recognized, and the call for a text-book upon Anatomy, Physiology and Hygiene which shall be up to the times in each of these different departments, has been growing louder and more emphatic, coming from State and County superintendents of education, teachers, students, and hygienists. One of the greatest faults generally recognized in the various text-books on this subject has been the universal lack of practical information on the subject of hygiene. In many instances too much attention has been given to the technicalities of anatomy, requiring the student to memorize hundreds of Greek and Latin names which do not by any means represent a proportionate number of practical facts.

Another very general fault with school text-books upon this subject has been the failure of their authors to present the very latest information on all the subjects treated. Physiology and Hygiene are

not fixed sciences like logic, mechanics, and mathematics, but are yet in a forming state, each day bringing out new and important facts which must be recognized in order to enable one to be really intelligent on the subject.

In this work we have endeavored to avoid some of the errors of other writers, though possibly we may have fallen into others equally grave. Whether or not we have succeeded in approaching any nearer to the standard of what a perfect text-book of Anatomy, Physiology and Hygiene ought to be, will be determined by those who make an actual trial of the merits of this work.

The subject matter of this work is essentially the substance of the series of lectures which we have given annually for the last five years before classes in Battle Creek College and in the School of Hygiene. Those who have listened to the lectures referred to, will notice numerous improvements and additional facts, which are largely the result of the study of recent medical literature in the Medical Library of the Army and Navy Museum located at Washington, D. C.

In conclusion, we would invite the friendly criticism of teachers and others into whose hands this book may fall, trusting that by the aid of such kindly assistance we may be able to improve the work in future editions until it shall fully meet the present urgent want of a text-book of Anatomy, Physiology, and Hygiene, for schools, which shall give just the proper kind and amount of information upon each branch of the subject, and shall present the newest and most reliable facts established up to the day of publication.

J. H. K.

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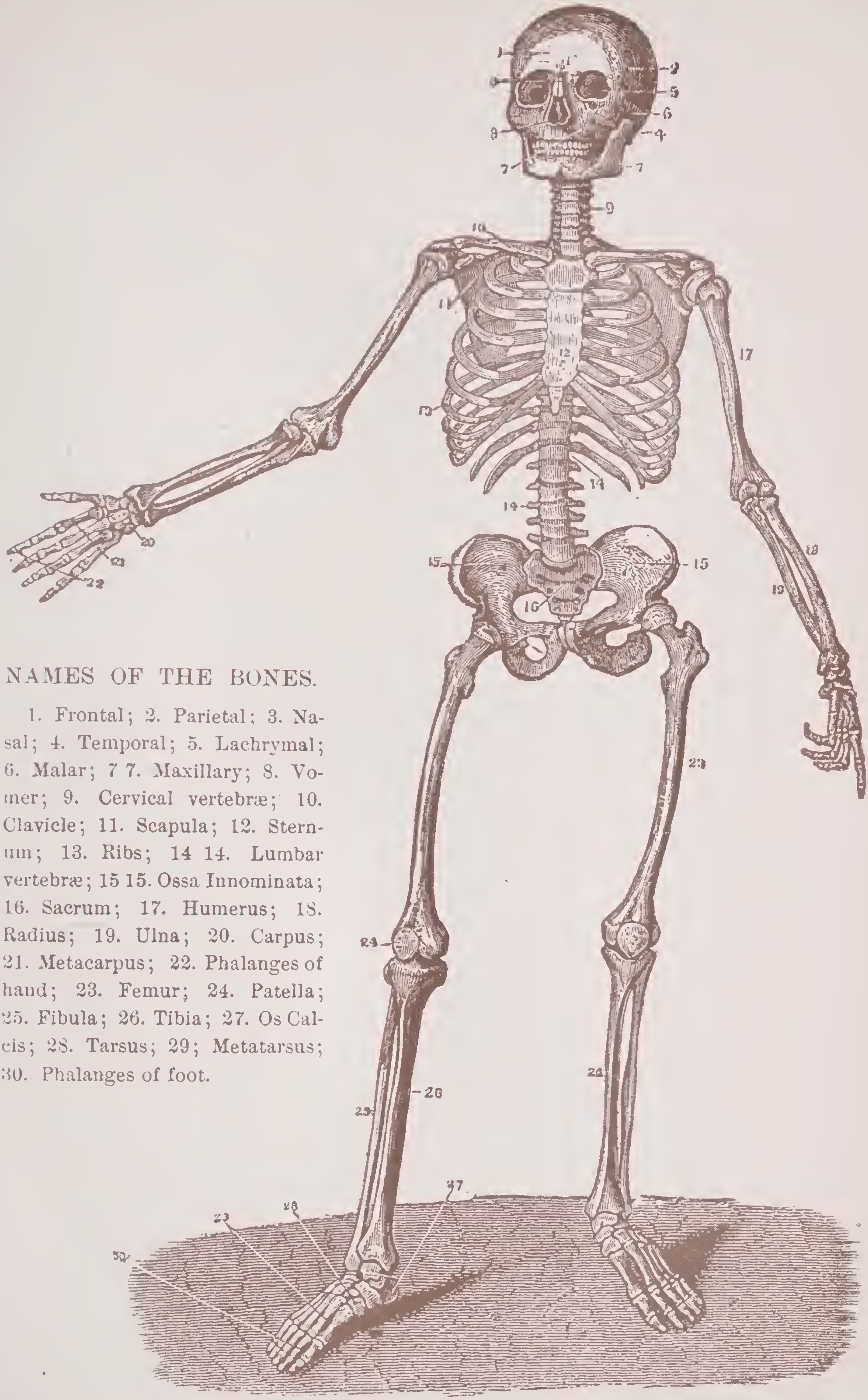


NAMES OF THE BONES.

1. Frontal; 2. Parietal; 3. Nasal; 4. Temporal; 5. Lachrymal; 6. Malar; 7 7. Maxillary; 8. Vomer; 9. Cervical vertebræ; 10. Clavicle; 11. Scapula; 12. Sternum; 13. Ribs; 14 14. Lumbar vertebræ; 15 15. Ossa Innominata; 16. Sacrum; 17. Humerus; 18. Radius; 19. Ulna; 20. Carpus; 21. Metacarpus; 22. Phalanges of hand; 23. Femur; 24. Patella; 25. Fibula; 26. Tibia; 27. Os Calcis; 28. Tarsus; 29; Metatarsus; 30. Phalanges of foot.

Plate I.—*THE SKELETON.*

PLATE II.—*THE MUSCLES.*

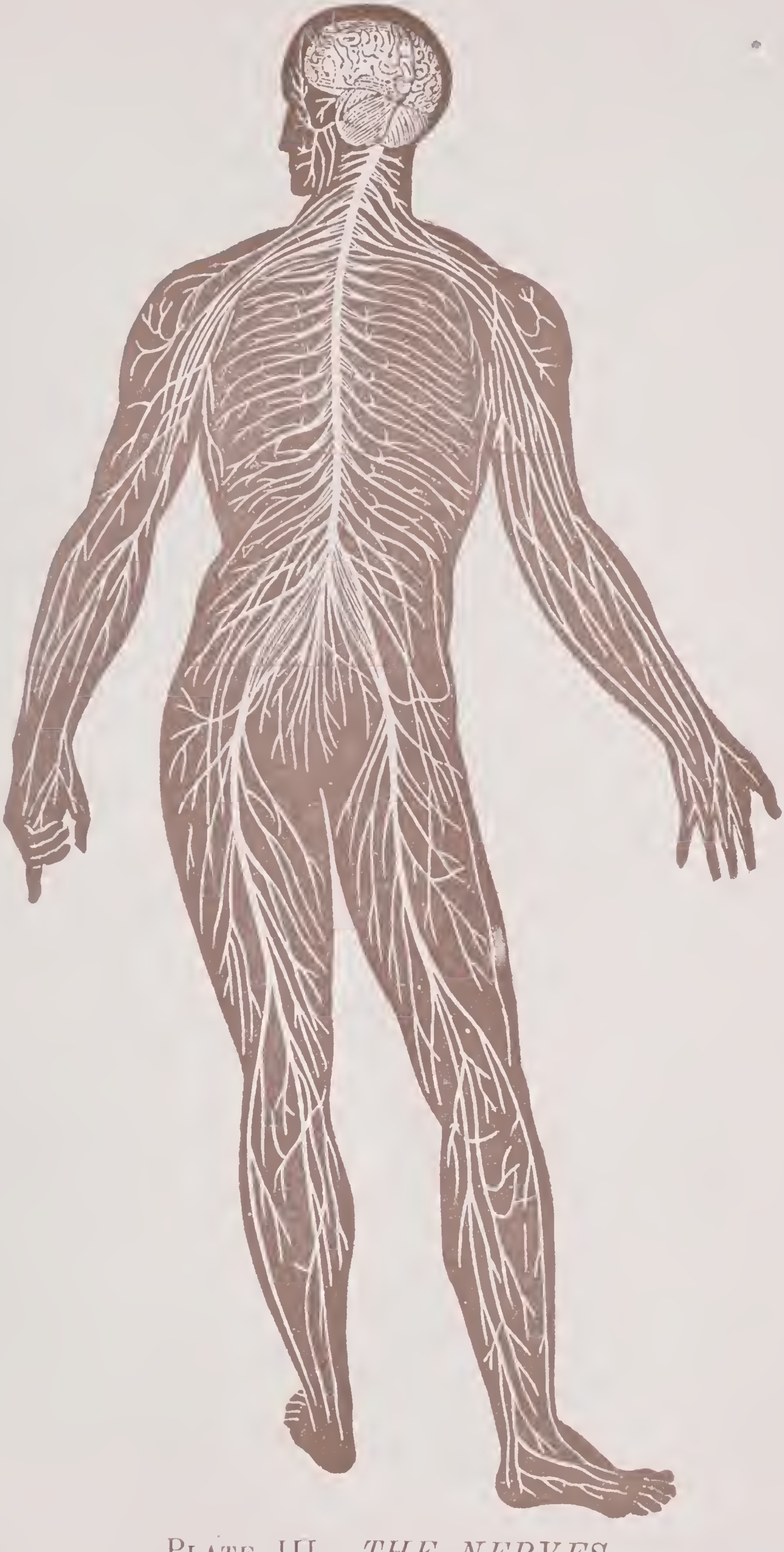
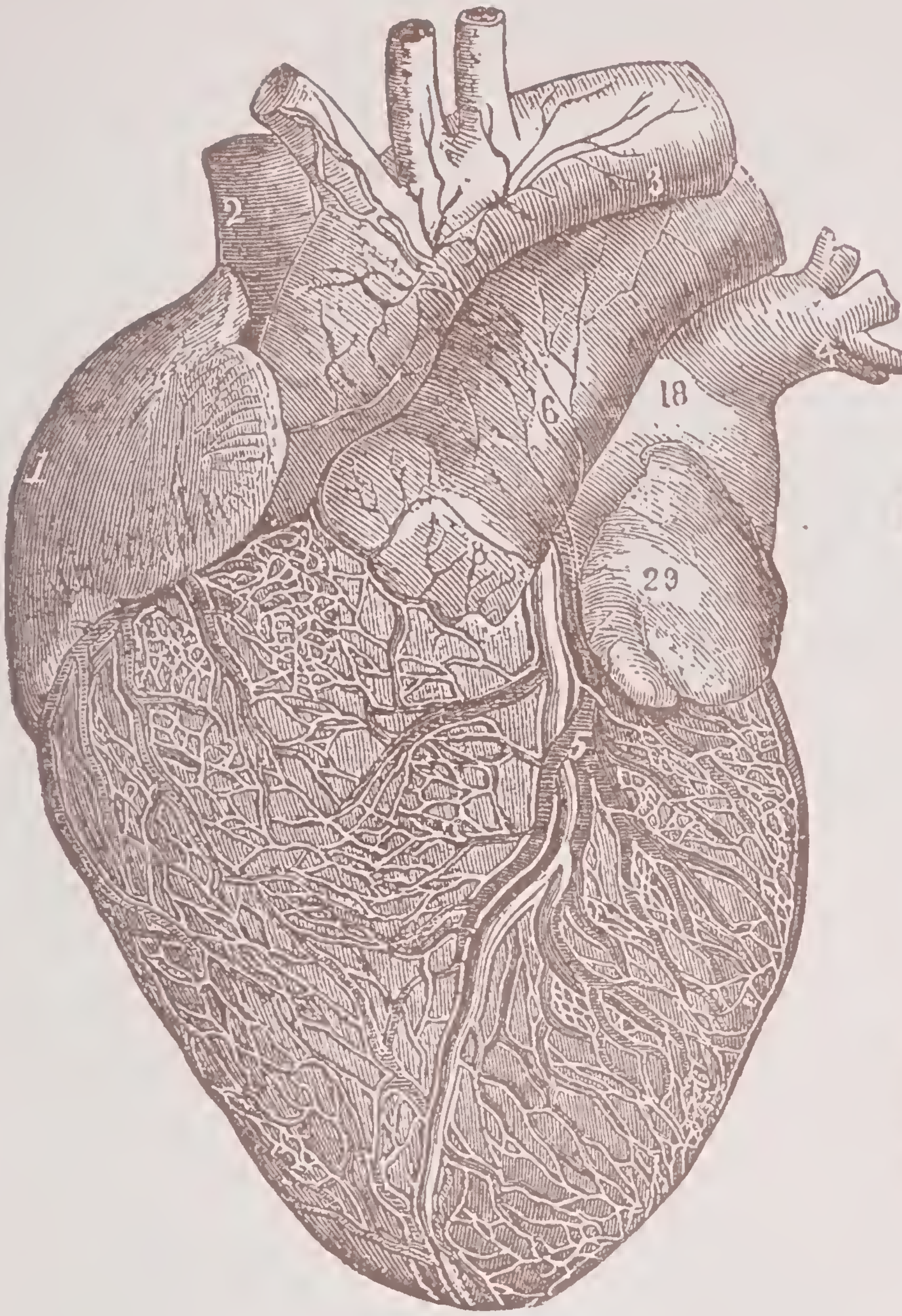


PLATE III.—*THE NERVES.*

PLATE IV. *THE SKIN*

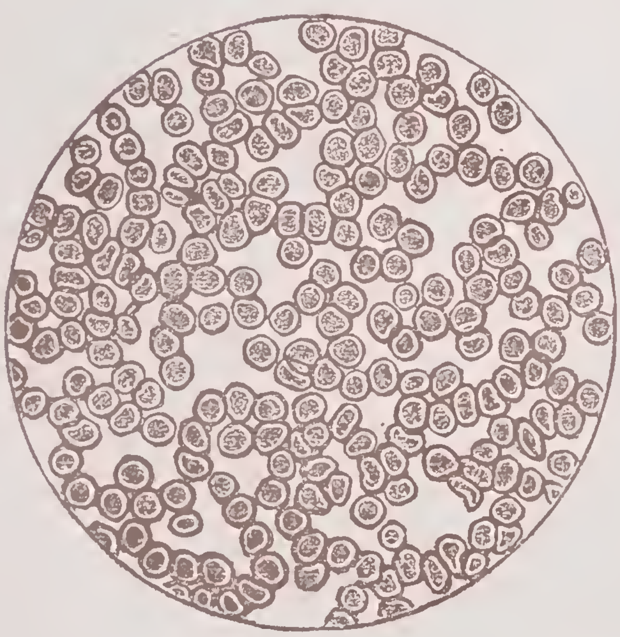
Showing a Vertical Section of the Skin, greatly magnified. *a. a.* Hairs in their follicles, connected with which are the Sebaceous Glands; *c.* Sweat Gland with its duct; *d. d.* Blood-Vessels.



A

B

C



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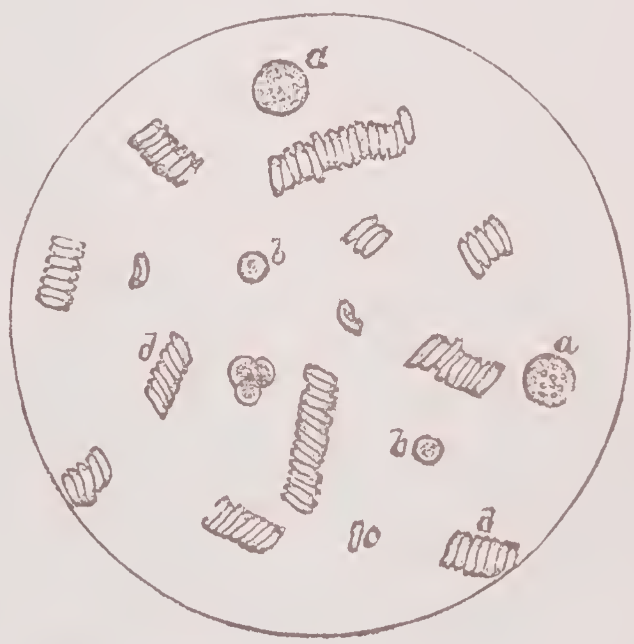
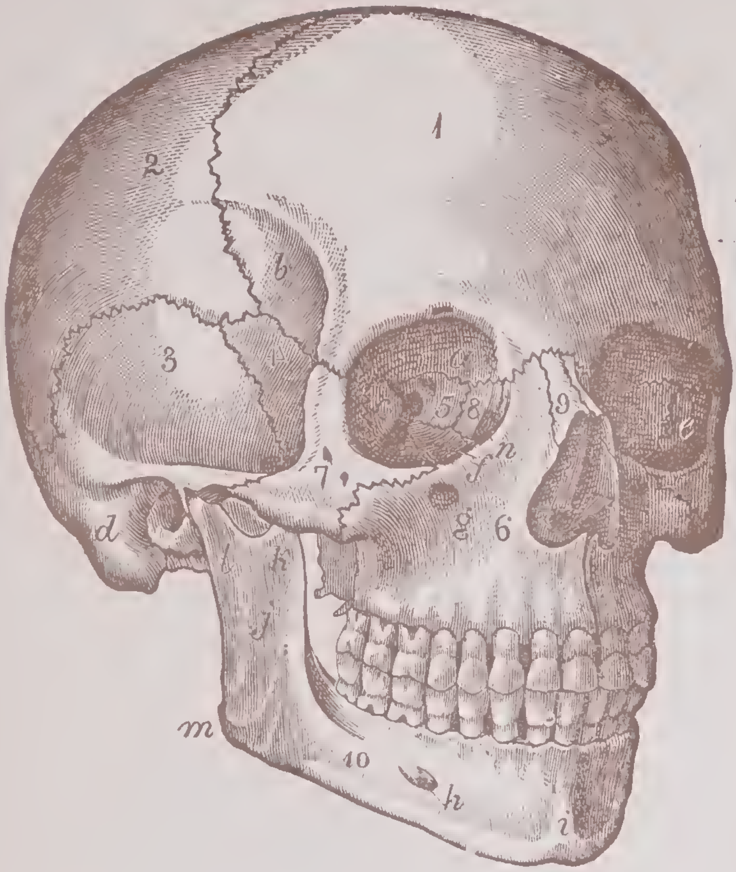


E

A. The heart, showing the origin of the large blood vessels; *B*. Toe of frog, slightly magnified; *C*. Circulation in foot of frog, greatly magnified; *D*. Red blood corpuscles; *E* Blood corpuscles, red and white—*a*. white, *b*. red.

PLATE VI.

BONES OF THE HEAD.



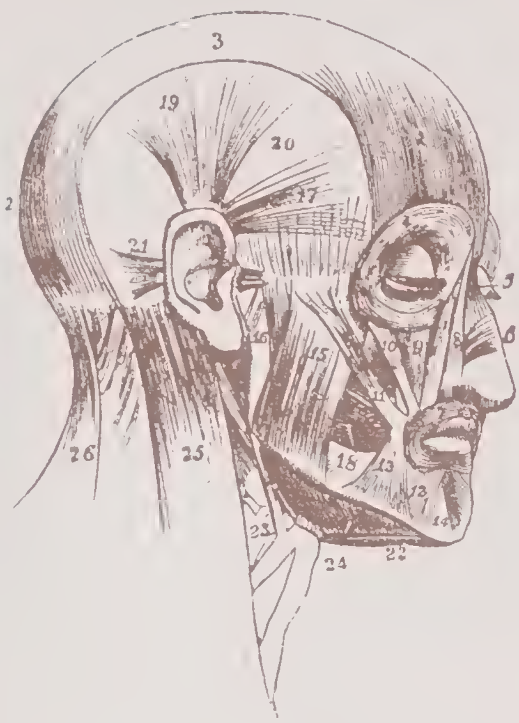
1. Frontal.
2. Parietal.
3. Temporal.
4. Sphenoid.
5. Ethnoid.
6. Superior Maxillary.
7. Malar.
8. Lachrymal.
9. Nasal.
10. Inferior Maxillary.

THE INTERNAL EAR.

1, 2, 3. Semi-circular canals.
4. Cochlea.
5. Vestibule.

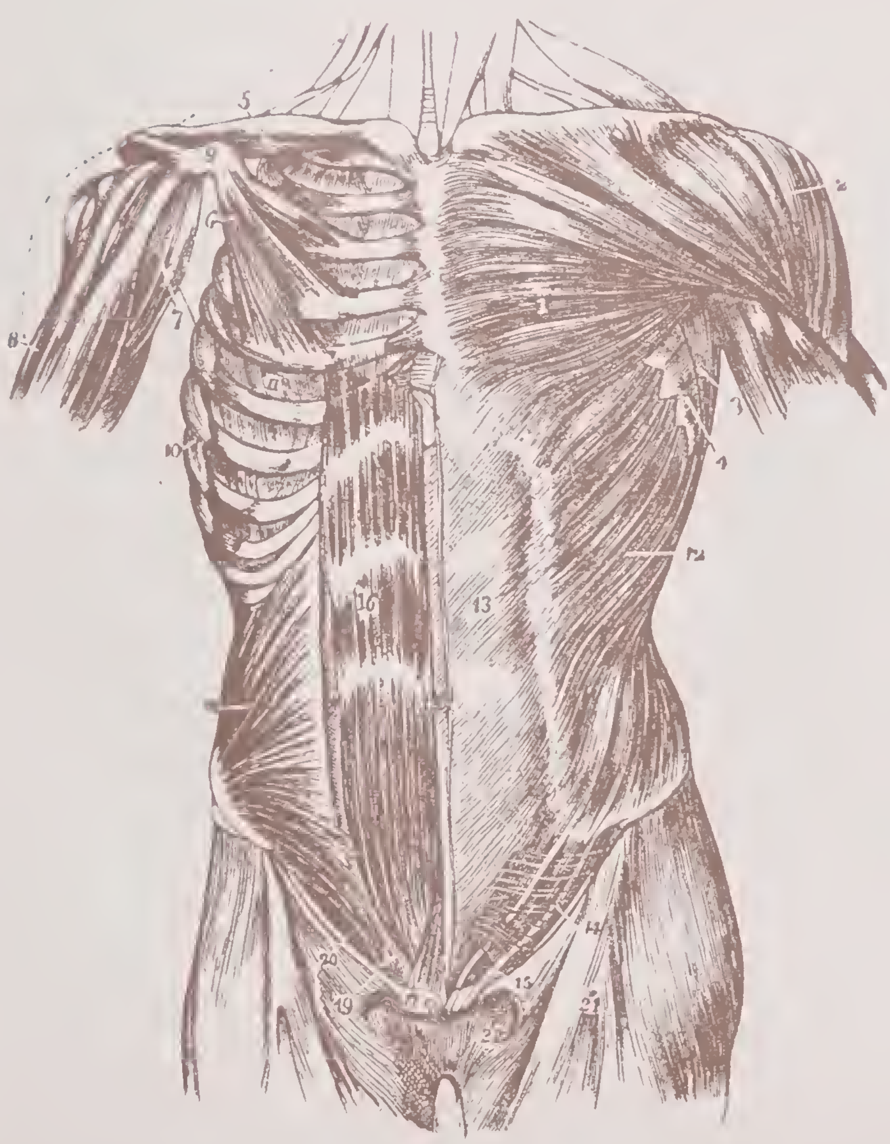
PLATE VII.

MUSCLES OF THE HEAD.



1, 2, 3. Occipito-frontalis.
4. Orbicularis palpebrarum.
5. Tensor tarsi.
6. Compressor nasi.
7. Orbicularis oris.
8. Levator labii superioris alaeque nasi.
9. Levator anguli oris.
10. Zygomaticus minor.
11. Zygomaticus major.
12. Depressor labii inferioris.
13. Depressor anguli oris.
14. Levator menti.
15. Masseter.
17. Attrahens aurem.
19. Attolens "
21. Retrahens "
22. Digastric.
24. Glossal muscles.
25. Sterno-cleido-mastoid.
26. Trapezius.

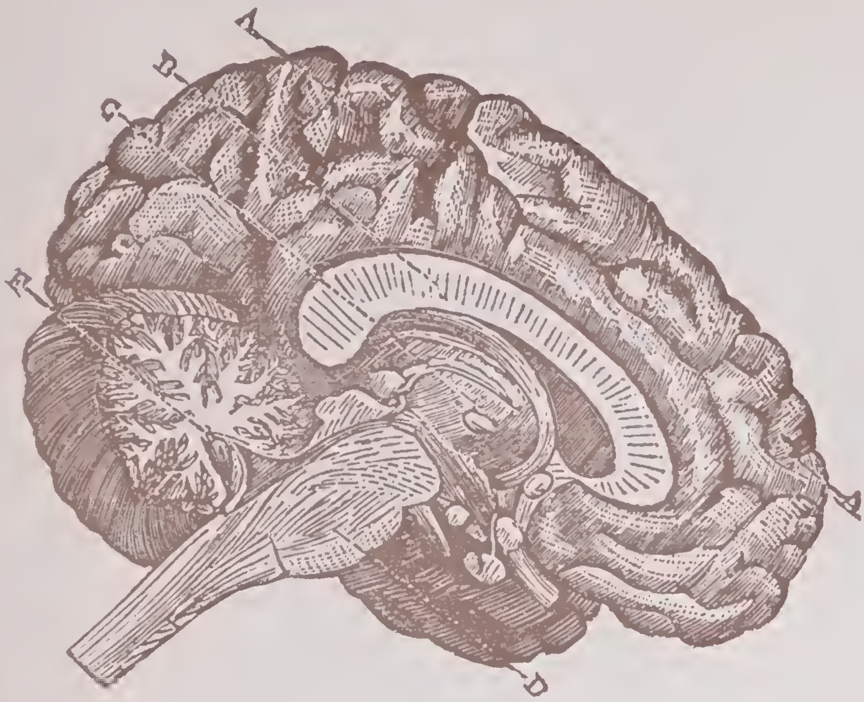
MUSCLES OF THE TRUNK.



1. Pectoralis major.
2. Deltoid.
3. Latissimus dorsi.
4. Serratus magnus.
5. Subclavius.
6. Pectoralis minor.
7. Coraco-brachialis.
8. Biceps.
10. Intercostales.
12. External oblique
14. Sartorius.
16. Rectus abdominalis.
18. Transversalis

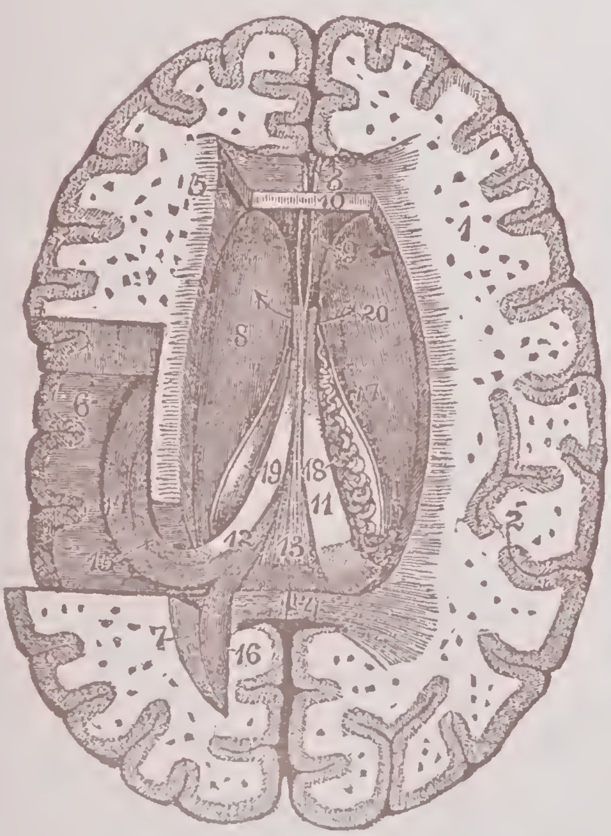
PLATE VIII

VERTICAL SECTION OF THE BRAIN BETWEEN THE HEMISPHERES.



A. A. Left half of the cerebrum.
B. Corpus Callosum.
C. Optic Thalamus.
D. Pons Varolii.
E. Upper end of spinal cord.
F. Divided portion of cerebellum showing arbor vitæ.

HORIZONTAL SECTION OF THE BRAIN.



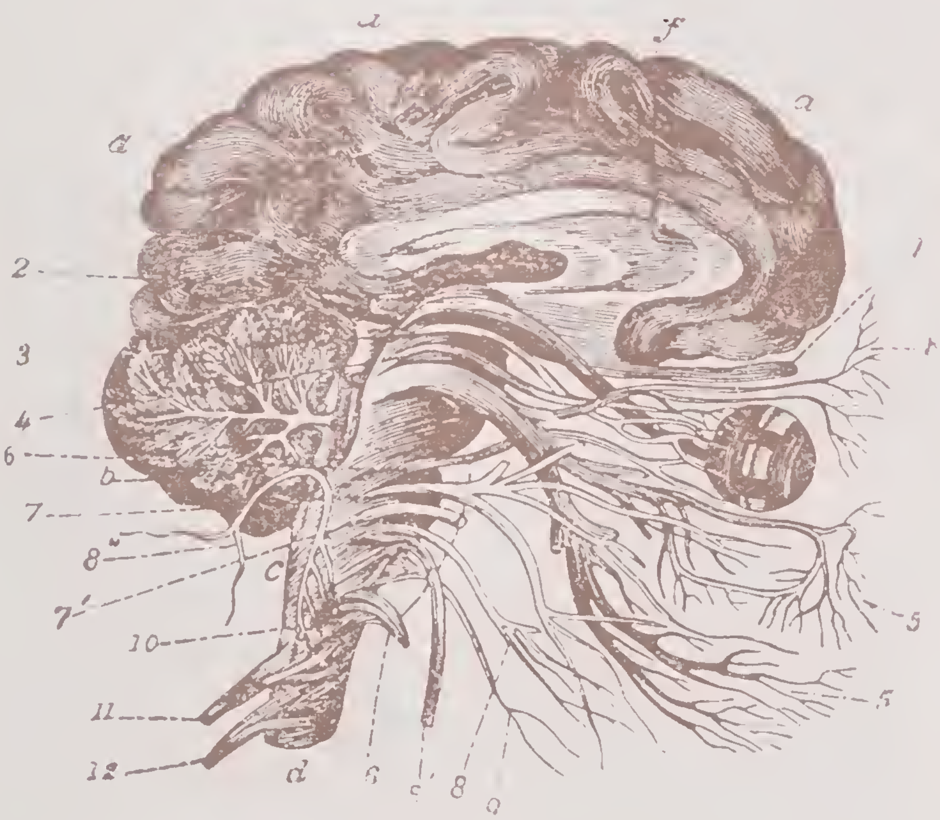
1. White tissue of the brain.
2. Gray tissue composed of cells.
3, 4. Corpus callosum.
8. Corpus striatum.
14. Hippocampus.
18. Choroid plexus.
10. Optic thalamus.

PLATE IX.

VIEW OF UNDER SURFACE OF THE BRAIN.

1, 2. Longitudinal fissure.
3, 3. Anterior lobes.
4,4. Middle lobes.
6, 6. Posterior lobes.
7, 7. Cerebellum.
9, 9. Olfactory lobes.
11. Tuber cinereum.
12, 12. Corpora albicantia.
14. Origin of third nerve.
15. Crus cerebri.
16. Pons varolii.
17. Origin of seventh nerve.
18. " " fourth "
19. " " fifth "
20. " " sixth "
22. " " eighth "
26 " " ninth "

A VIEW OF THE CRANIAL NERVES.



a. a. a. Cerebrum.
b. Cerebellum.
c. Medulla oblongata.
d. Spinal cord.
1. Olfactory nerve.
2. Optic.
3. Motor oculi.
4. Pathetic.
5. Trifacial.
6. Abducens.
7. Facial.
8. Auditory.
9. Glosso-pharyngeal.
10. Pneumogastric.
11. Spinal accessory.
12. Hypoglossal.

PLATE X.

THE SYMPATHETIC NERVOUS SYSTEM.

A, A. Semi-lunar ganglion and solar plexus.
B, C. Tri-splanchnic nerves.
D, D, D. Nerve centers of the thorax
G. Coronary plexus.
I–T. Cervical glands and branches.

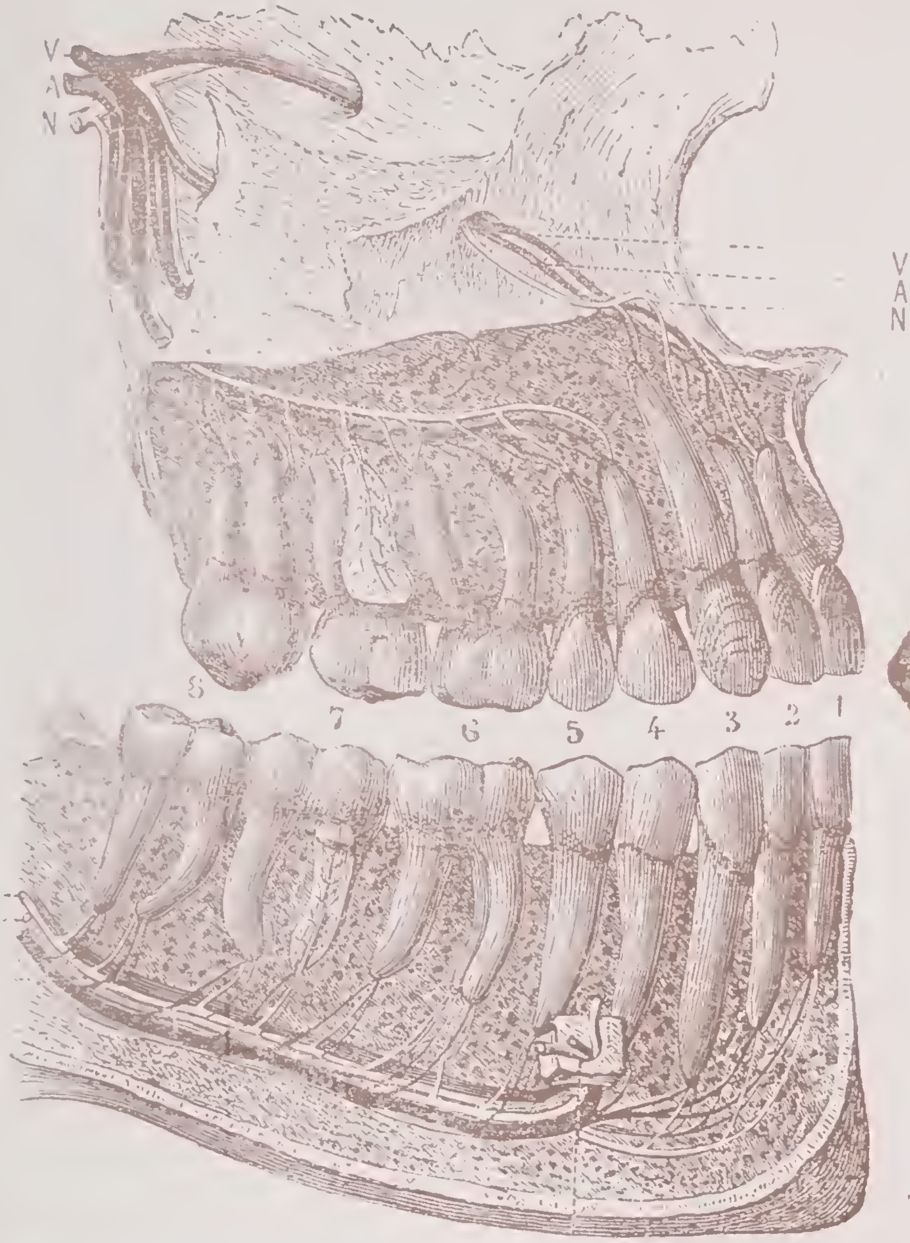
Pork infected with trichininæ capsules.

Same as preceding, but considerably magnified.

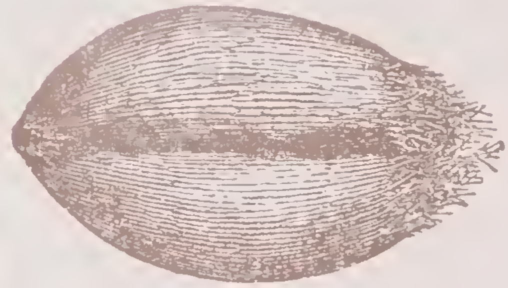
Measly pork, showing tape-worm cysts.

PLATE XI.

THE TEETH.



V. Vein.
A. Artery.
N. Nerve.
1, 2. Incisor teeth.
3. Cuspid "
4, 5. Bi-cuspid or small molar teeth.
6, 7, 8. Molar or double teeth.



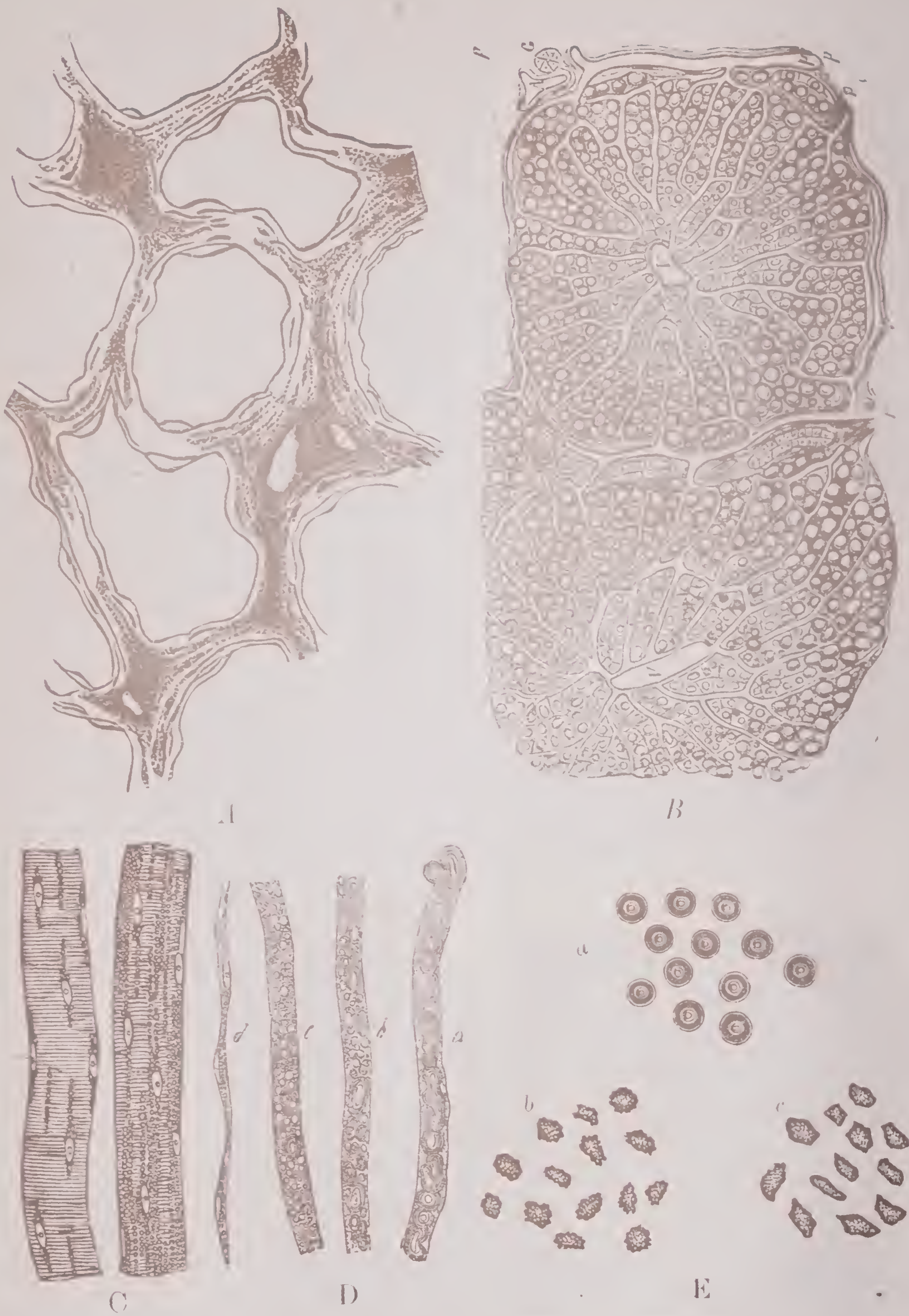
A grain of wheat magnified.

The same deprived of its rough outer coat.

Starch granules.

Transverse section of grain of wheat greatly magnified.

PLATE XII.



A. Lung tissue filled with charcoal dust ; *B*. Fatty liver, effects of alcohol ; *C*. Fatty muscle,—effects of alcohol ; *D*. Fatty nerve fibres, from use of alcohol ; *E*. *a*. Healthy blood, *b*. Shows effects of tobacco, *c*. Shows effects of alcohol.

PLATE XIII.

Fig. 1.

Fig. 2

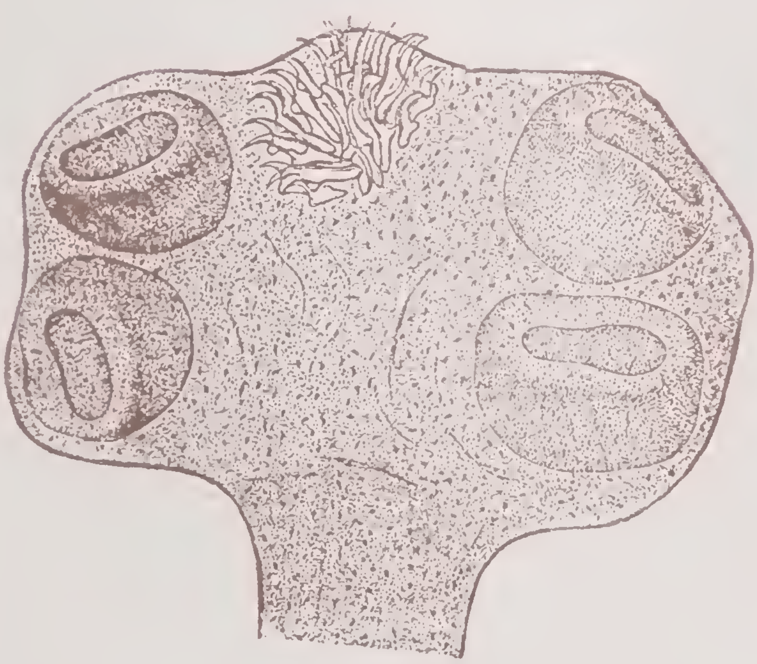


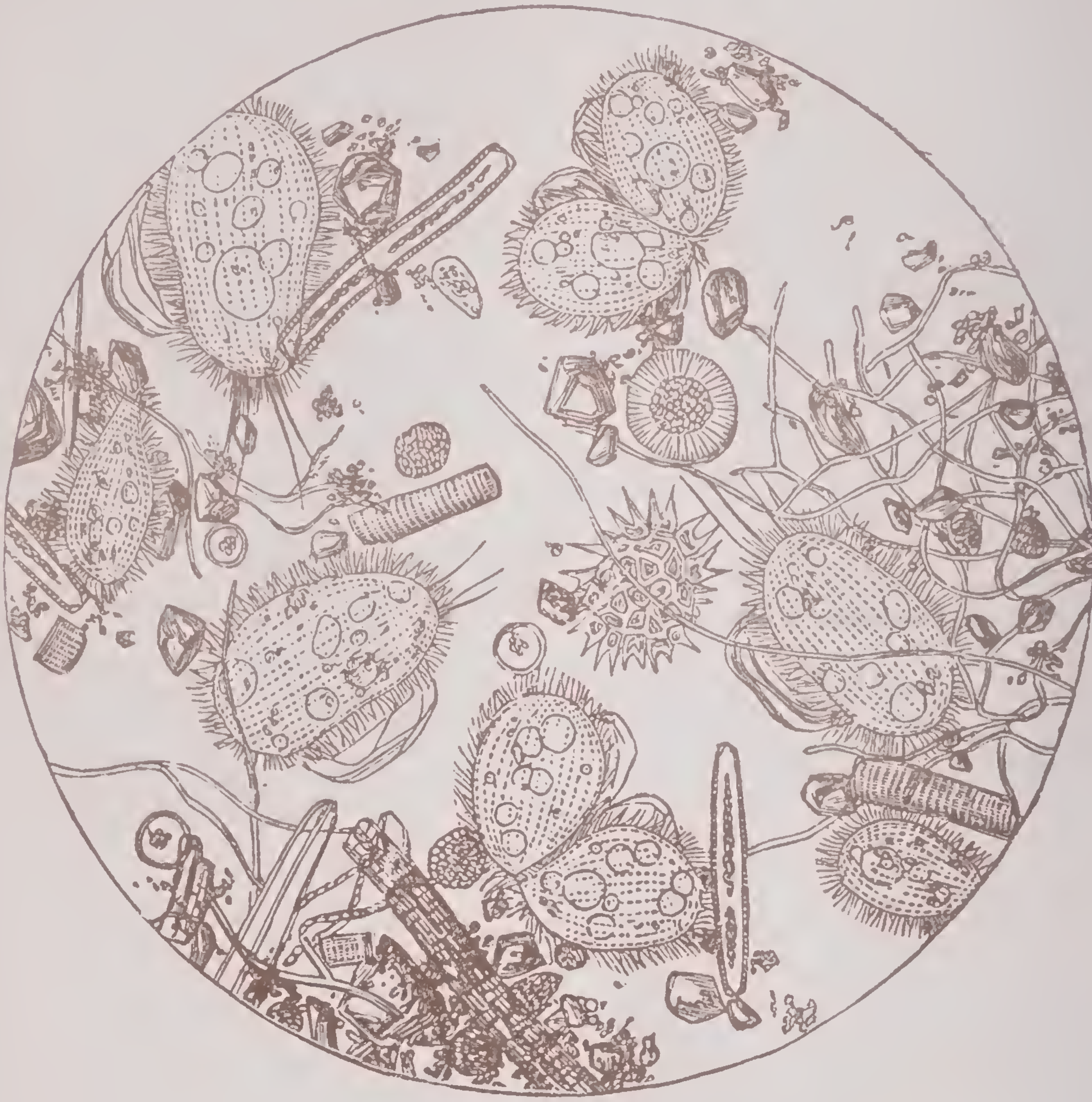
Fig. 3.

Fig. 4.

PLATE XIV.—*HUMAN PARASITES.*

FIG. 1. Trichinæ lying loose among the muscular fibres as seen in a piece of ham newly infected. FIG. 2. Single Trichina in its capsule, some weeks after infection. FIG. 3. Head of a Tape-worm greatly magnified. FIG. 4 Thread Worm.

ANIMALCULES AND INFUSORIA IN WATER.



The above cut shows a great variety of different forms of animalcules and other minute organisms which are to be found in water containing organic matter. They were not all found in a single specimen, but represent the results of a large number of examinations made by Dr. Hassall of the water used in London for drinking purposes.

PLATE XV.

ANATOMY, PHYSIOLOGY, AND HYGIENE.

Definitions.—*Anatomy* is derived from two Greek words which literally signify to cut, or dissect. The word is used to designate the study of the form, structure, and other apparent properties of organized bodies, whether animal or vegetable. In our use of the word it will be confined to the study of the human form. *Comparative anatomy* is the study of each separate organ of an animal as compared with corresponding organs in other animals; this is one of the most fascinating and instructive branches of science. Our space will not allow of the extended study of this division of anatomy, but we shall call attention to some of the more interesting and important points connected with the subject.

Physiology is a term derived from two Greek words which literally mean a description of nature. When first coined by the ancient Greeks the word meant essentially the same as does the term *physics* at the present day. The philosophers of ancient Greece led their pupils about among the fields, through forests, and beside the lakes and rivers of that picturesque country, discoursing of the various animals, plants, rocks, and other natural objects which attracted their attention. This was a literal study of nature, and the study was called physiology. The term is now used to denote the science of the functions of living creatures. We have *vegetable physiology* as well as *animal* and *human physiology*. There is also *comparative physiology*, the complement of comparative anatomy, already defined, which relates to the comparative study of the functions of various animals.

Hygiene is a word taken directly from the French language. It is used to signify the study of those laws which relate to the healthy action of the various organs of the body. It is one of the most important and practical of all the subjects with which we have to deal, and will receive a proportionate amount of attention, both in connection with the study of the anatomy and physiology of the several organs of the body, and in chapters especially devoted to the subject.

Man's Place in Nature.—Much has been said of late regarding man's place in nature, the general drift of the discussion of the subject being to show that man is but the final product of a process of development which in the course of some millions of ages has raised him from a mere speck of dust to his present position at the head of all animate objects which come within the scope of our knowledge. It is not in this sense that we wish to speak of man's position in the universe. We wish to direct the reader's attention to the following facts:—

1. That man is a part of the material universe. Whatever theory may be held respecting his nature, whether it is partly material and partly spiritual, being double, or whether wholly spiritual as affirmed by some or wholly material as claimed by others, it is generally conceded that *science* recognizes man only as a material object, a part of the great universe of matter, wonderfully complex in his constitution and organized with the most marvelous delicacy, yet no less a part of the world of matter which appears on every hand in such wondrous diversity of forms.

2. That man is subject to the same general laws which govern other material objects. The same destructive agents which effect nearly all the changes in matter, fire, water, gases, and various chemical agents, operate upon man as upon other material objects. The law of gravitation holds him to the earth in precisely the same manner as though he were a stone. Electricity, that most potent of all the subtle, unseen agencies of nature, operates upon man as upon other objects, animate or inanimate, using him as a conductor when no more easy passage is at hand, utterly disregarding his presence or existence when a more facile route is offered. So with all the agencies and forces of nature.

3. That the special laws which govern all organized bodies relate to man in common with all other animals and vegetables. It will be clearly seen by our future study of the human constitution that man is but a part of the general scheme of organization which includes all animal and vegetable life. Man is not a vegetable, but possesses many things in common with the lowest forms of vegetable life, even the microscopic mold which vegetates upon a stale fragment of bread.

The Constitution of Matter.—In order for us to fully understand the varied relations of the human form divine to the rest of the universe, we must first study physiology in its broad, original

meaning; that is, we must study nature as a whole sufficiently to gain a knowledge of the great general laws which lie at the foundation of all existence animate or inanimate. By this study we shall discover that a senseless, lifeless stone may rightfully claim kinship with a king upon his throne. We shall learn that there is a common brotherhood existing between all material things. Nor will this knowledge, as some might fear, in any degree detract from the dignity of man, the lord of creation, though it will add to the dignity of many objects which we are, through the influence of early erroneous education, inclined to look down upon.

Before entering upon a more precise account of the nature and constitution of matter, we must premise a few points with which we are sure all candid, thinking persons will agree.

1. We possess very little positive knowledge on any subject. Whenever we attempt to get back to fundamental propositions, we find that nearly all our reasoning is based upon assumptions.

2. Nevertheless we must have something as a starting-point in all lines of thought or reasoning; and in the absence of absolute or positive knowledge, the only proper course left for us to pursue is to assume that which is *the most probable.*

3. That which all will agree in accepting as the most probable is that which presents the most evidence in its favor, even though none of the evidence may be absolutely conclusive.

4. The various organs of sense are our only means of receiving knowledge; hence we must accept the evidence of the senses, weighed by reason, as to what is most probable.

Matter the Basis of Existence.—Viewing the subject in the light of the propositions stated, we are shut up to the conclusion that *matter is the basis of all existence.* We do not affirm that there is no other than material existence. We know that there must be, since ideas, qualities, and all abstract things exist, though immaterial; but still, science recognizes matter as the basis of all, since abstract existence is only possible through the relation of abstract to concrete things. To illustrate, sweetness cannot exist independent of some sweet thing, and depends for its existence upon that object. So with all other properties, qualities, and relations. Science does not deny the existence of other than material entities, but does declare its inability to recognize them, since it can deal only with material things, which must be evident to all when it is recollected that man possesses

only seven senses, none of which are capable of recognizing any other than material objects. Any knowledge of immaterial objects must be obtained elsewhere than through scientific investigation. In this, all scientists are agreed.

The Nature of Matter.—All the evidence we have on this subject points to the conclusion that all material things are composed of infinitely small particles which are indivisible, and which possess certain properties common to all forms of matter. For instance, we will suppose that we take a rock and grind it into an impalpable powder. Now we will take as small a quantity of this dust as will adhere to the point of a pin. Placing it upon a perfectly clean slip of glass, we will look at it with a powerful microscope. The invisible particles now appear each like a great rock rivaling in proportions the original mass. Now, by means of delicate appliances, we will divide one of these portions into particles so fine as to be invisible even with the microscope employed. A much more powerful instrument still brings them into view. Another subdivision by chemical means places the particles beyond the power of any microscope, yet the spectroscope will still discover their presence, so that we know they are not lost. So far as our knowledge goes, no further subdivision can be made, and the ultimate, invisible particles are known as atoms.

Atoms do not exist separately, but are combined in groups, which are known as molecules.

The size of atoms cannot be accurately known; but it has been determined within certain limits by calculations based on very probable data, the results of which seem to show that if an apple were magnified to the size of the earth, the atoms which compose it would be not larger than cricket balls nor smaller than fine shot.

Force and Atoms.—A mischievous doctrine has been taught from early ages down to the present time respecting the nature of force and its relations to matter and material objects. The ancient and popular view has been that force is a separately existing something which operates upon matter and material objects, producing all the various changes and operations observable in matter. Science has in modern times thoroughly exposed the fallacy of this theory. What evidence we have on this subject goes to establish the view that force is but a property of matter, and that it is inseparably connected with matter. That matter and force are inseparable is quite patent when we attempt to conceive of either one as existing alone. Such a conception

is as impossible as the formation of an idea concerning a thing which is utterly devoid of properties.

It is further established by philosophical research that each atom possesses a certain definite amount of force, which is of necessity unchanging. This force may be sometimes active in one way, and sometimes in another, but is always present.

We do not need to trouble ourselves with the various theories respecting the exact nature of atoms, since the general principles laid down hold equally good with all. Whether atoms are hard, indivisible particles, or whether they are something different, does not matter, since we do know that they possess certain definite properties, many of which have been determined. It may be, indeed, that, as not a few eminent philosophers have supposed, there is but one fundamental atom and one primary force; still, our reasoning holds good.

Organization.—As matter is the basis of material existence, so organization is the basis of life in its great diversity of forms. This question has been the subject of an almost endless amount of discussion, which we shall not attempt to review here. We will simply state as before, and we do so without fear of successful contradiction, that what evidence we have on the subject leads directly and irresistibly to the conclusion that life is the result of organization, being the manifestation of the forces of nature connected with matter, modified by a peculiar arrangement. This special arrangement, which occasions the peculiar manifestations constituting the phenomena of life, is what is known as organization. All that makes a plant different from the soil out of which it grows, and the air and water which nourish it, is the peculiar arrangement given to the various elements which are taken in from the surroundings of the plant. The organization of a plant is analogous to the organization of an army or a government, simply an arrangement of the component parts. Each particular plant has its own peculiar arrangement, just as each particular government has its peculiar organization. Destroy the organization, and the life which depended on it is also destroyed. What is true of a plant is also true of an animal, and of a human being.

Lowest Forms of Life.—A little speck of scum from a stagnant pool or a drop of slime from a moist rock by the sea-shore, when viewed with a good microscope, is seen to be almost wholly made up of minute living organisms. Stagnant water always teems with these low forms of life. In some localities the bottom of the sea is covered

with them. Some of the simplest forms of these minute organisms are mere specks of life which do not differ much in appearance from particles of dust. Indeed, eminent observers have not infrequently confounded these curious little living atoms with inanimate dust. A close inspection, however, shows that they possess some very different properties from dust particles; in other words, that they are alive. Other forms appear like little drops of jelly. Round, transparent, they might be easily mistaken for bubbles or masses of some gelatinous substance were it not that now and then they will be seen to move. If watched closely, it will be observed that they change their form and position, and even eat. They possess no eyes, no mouth, no teeth, no organs of locomotion, in fact are nothing apparently, but tiny jelly drops; and yet they seem to be conscious, they move about from place to place, and feed upon the little particles with which they come in contact.

Here is life in its most lowly form. It is not hard to think that these tiny creatures, so like the inanimate particles with which we are familiar in the study of chemistry and physics, are but unique arrangements of the same matter which in other forms obeys the well-known laws of matter in its simplest forms.

The Basis of Life.—The little jelly drop sustains to higher organisms the same relation that the atom does to all other forms of matter. It is the basis of life. *Protoplasm* is the technical term which scientists apply to the atom of living forms. Out of these simple forms of life all higher and more complex organisms are formed. This is true of animals as well as vegetables. Take a man in pieces, and he will be found to be made of similar masses connected together by various devices. Dissect a tree, and the same will be found to hold true. Examine a drop of blood with a microscope, and it will be seen that the blood is simply a stream in which are floating, swimming, moving, and working, millions of little creatures so nearly like the microscopic creatures found in the scum of a stagnant pool that they have received the same name. The arteries and veins of the body may be looked upon as corresponding to the rivers and streams of a continent, and the blood corpuscles to the fish which swim in the waters.

The Scale of Being.—Man must be looked upon as a part of the great world of life. He is not a distinct and wholly unique creation, totally unlike all other living forms. The little mass of protoplasm

which swims in a drop of stagnant water is at one end of the scale of being, and man, with his magnificent and wonderfully complicated mechanism stands at the other. The two are connected by an unbroken chain of living forms which rise in complexity and superiority in regular gradations from the living atom in the speck of green scum to the human form divine at the summit of the scale.

The scale of life includes all living forms, not simply animals, as might be easily supposed. In all, protoplasm remains the same, always apparently identical, yet sufficiently different to give to the forms of life which it helps to constitute, individuality of existence and characteristic properties.

How Protoplasm Works.—See Figs. 1 to 8. There is nothing more interesting in all the realm of science than to watch with a microscope the operations of protoplasm. Let us study this wonderful phenomenon for a few minutes. In anticipation of wanting material for such a study, a few weeks ago we pulled a handful of grass from the lawn in front of our office, and placing it in a platter half filled with water, put it in a warm place. Now we bring out the platter and find that the grass has undergone partial decomposition. With a glass tube we draw up a few drops of the dirty-looking fluid in which the half decomposed grass is submerged, and placing a single tiny drop upon a clean slip of glass we put it in the focus of a powerful microscope. Adjusting the glass and the light perfectly, we soon see sundry shreds of brown grass, and numerous floating particles of dust and other foreign matter of no particular interest. If we had not sought a similar view many times before, we should soon put aside the instrument and turn our attention to something more attractive; but we have learned to look a little sharper, and now we are rewarded by seeing just what we were in search of, curious little round masses so transparent as to be almost invisible. They are not very numerous, but scattered here and there about the field. Presently we perceive that some are changing their form. A moment ago the first one we inspected was as round as a watch crystal; now it has become elliptical in form. A few minutes later we look again, and it has stretched itself out into a long filament like an angle-worm. Presently it begins to draw itself up into a round mass again; and before we can write it, it has assumed its original shape, but has changed its position. That is the way the little creature moves about. It makes itself into the shape of a worm and then crawls just as a worm does, by making one end

fast and drawing the rest of the body up. But what does it move about for? Why may it not remain stationary? Shortly we shall see if we watch carefully. Even now the reason is evident. Reader, just peep over our shoulder a moment. Put your eye down to the eye-piece of our microscope. Do you see the little fellow? Look sharp, and you will. A few seconds ago it was round as a full moon. Now there is a little pocket in one side. The pocket is growing

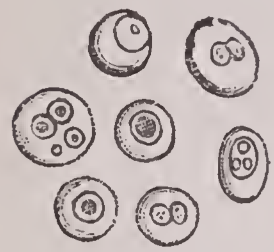


Fig. 1.

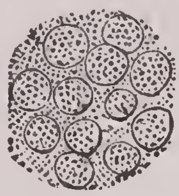


Fig. 2.

Fig. 3.

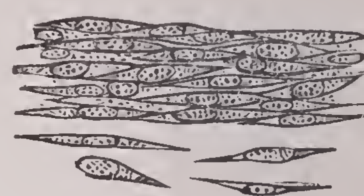


Fig. 4.

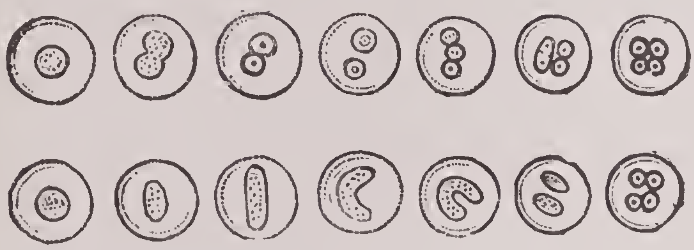


Fig. 5.

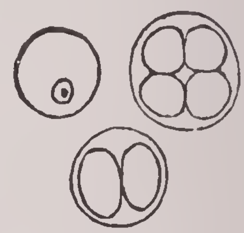


Fig. 6.

Fig. 7.

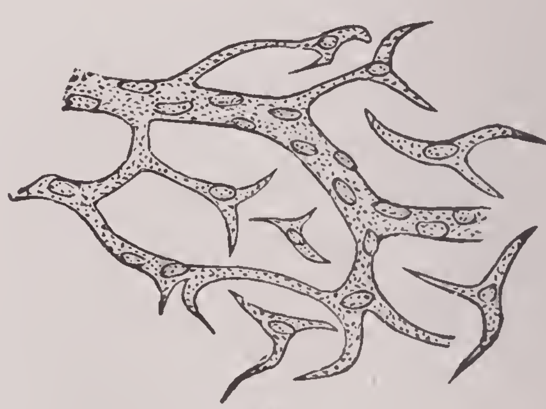


Fig. 8.

Figs. 1 and **5** represent cells in different stages of development. The dark bodies occupying the centers are nuclei.

Figs. 2, 3, and **4** show different varieties of cells.

Figs. 5, 6, and **7,** show how cells divide or multiply.

Fig. 8 is a representation of the manner in which cells unite by their arms to form capillary vessels.

deeper and deeper. What is the object of such a curious procedure? Let us put on another eye-piece. Now we have magnified the object a million times. See how much larger it looks. Now look at the pocket. The mystery is solved. There is a little speck of food which the little creature wishes to get, and so he has made a pocket to put it in. The queerest part is to come yet, so we must watch patiently a moment more. Now the mouth of the pocket is closing up. Evidently the little fellow is afraid he may lose the precious morsel, and

so he is going to shut the pocket to prevent its escape. Now the opening is closed, and before we are aware of it, the pocket itself has disappeared, and there is the little particle inside. This seems a miraculous process, but it is the peculiar way these little creatures have of taking food. When they wish to eat, they make a mouth or a stomach on purpose. If we wait a few minutes we shall see that the little particle taken in has disappeared. It has been digested. Thus the lowest forms of life can perform some of the same functions which higher animals and vegetables perform, but by much simpler processes.

The smaller living creatures are, the more remarkable seem to be their powers. As we become better acquainted with protoplasm, it does not seem so strange after all that it should be capable of making a plant, painting a flower, building a tree, or even of forming a man; and that is just what it does. How, we shall see further on when we study the various tissues of the body. Let us now consider some of the principal differences between inorganic and organized or living matter.

Differences between Inorganic and Organized Matter.—Matter that does not manifest life in any form is called inorganic; living matter is said to be organized, because life depends upon organization. The following table exhibits the principal differences between these two forms of matter:—

INORGANIC MATTER.	ORGANIZED MATTER.
1. Not alive.	Alive.
2. Usually has angular outlines.	Characterized by rounded forms.
3. Has a crystalline structure.	Has a cellular structure.
4. Grows by accretion.	Grows by assimilation.
5. Does not reproduce itself.	Reproduces itself.
6. Does not ferment or decay.	Ferments or decays.

1. Inorganic matter, such as sand, rocks, and all forms of mineral, earthy, and gaseous bodies and chemical compounds, never exhibit the peculiar phenomena which are commonly known as life. These phenomena are confined wholly to plants and animals.

2. Nearly all inorganic objects, unless artificially modified in form, have angular outlines, being usually bounded by straight lines. Organized bodies are bounded by curved and graceful outlines.

3. Most inorganic bodies are crystalline in structure, or are made up of particles which at some time have been crystals. Organized bodies, on the other hand, are generally composed of cells. A cell

consists of a mass of protoplasm, which is sometimes surrounded by a thin wall.

4. Inorganic bodies grow by accretion, that is, by additions to the outside, of matter of the same kind. The increase in size of a snow-ball is a good illustration of growth by accretion. Organized bodies, on the contrary, grow by assimilation, that is, by taking into themselves, from the outside, matter of an unlike character and making it into their own kind of tissue. Thus, a plant grows by taking in food through its roots and leaves; an animal, by taking food into its stomach, assimilation taking place in both.

5. Reproduction is a process wholly peculiar to organized beings. Stones never reproduce their kind. All organized bodies possess the power to create new beings like themselves. Reproduction is really a process of creation, and as such is the most wonderful of all the phenomena of life.

6. Fermentation and decay are processes by which a living organism returns to the inorganic state, which is commonly known as death. As inorganic bodies do not possess life, of course they cannot lose it.

The classification of all objects into inorganic and organized is not strictly correct, since this division does not include a peculiar class of substances not strictly belonging to either of the two mentioned, since it possesses some of the properties of each. These substances may be distinguished as organic. They are not organized, since they have not a cellular structure, and are often crystalline; yet they are manifestly not wholly inorganic, since they are subject to fermentation. Sugar, starch, fat, albumen, and sundry other substances which are generally known as proximate elements, belong to this class.

Animals and Vegetables.—If we should scrape from the surface of an old watering-trough some of the slime which is commonly found in such places, and submit it to examination with the microscope, we should find it to be composed almost wholly of living creatures of almost every imaginable form, possessing wonderful activity, and going through the various processes of life common to higher orders of living beings. Should the question be asked, Are these curious organisms animals or vegetables? we might find it more difficult to answer than would be at first imagined. Very likely we should at first call them all animals, since they appear to be swimming about, seemingly possessing volition as distinctly developed as in fishes, birds, and larger animals. But a more careful study of the subject would

show us our mistake. The general ideas regarding the distinctions between animals and vegetables hold good only regarding the higher orders of animals and vegetables. In the lower orders nearly all of these distinctions disappear. For example, it is generally supposed that animals alone possess the power of locomotion, vegetables remaining stationary wherever they happen to begin their growth. This is not true with the lower orders, as microscopic vegetables move about in the water as freely, and apparently with as much volitionary power, as animals. These minute plants are indeed actually provided with organs for swimming or otherwise propelling themselves in the water. The same discrepancy is found respecting the other distinctions formerly laid down. The difference between the two classes is, in fact, finally narrowed down to a mere question of diet. If carefully watched, the various minute organisms under observation will be seen to take different kinds of food. Individuals of one class draw nutriment from the inorganic matters held in solution in the fluid in which they float; those of the other subsist upon solid particles of organized matter, perhaps even indulging in an occasional meal upon creatures of their own kind. Here is the primary distinction which, with a single exception, holds good with all the various species of animals and vegetables: vegetables feed upon inorganic matter, animals upon organized matter. There is no exception to this rule among animals; but among vegetables there is the one exception of the class of cryptogamous plants known as *fungi*, which subsist upon organic and organized matter instead of upon inorganic.

Distinctions between Man and Beast.—Man is an animal, but is not a beast; at least he should not be a beast, though some men will insist in placing themselves on a level with the brute creation. Man stands at the head of the animal kingdom, the peer of all animate creatures, but not above and outside of the great family of animal existence. Although man is an animal, and as such is related to all the lower orders of animal life, yet he possesses faculties and powers which are not only superior in degree, but some which are totally different in kind from any enjoyed by the lower orders. In order that we may correctly understand man's relation to the rest of the animate, creation we must consider the difference between him and lower animals. Without giving attention to minor points, the following may be stated as the most prominent features of difference:—

1. Man has a chin; the beast has none.

2. Man stands erect; no beast naturally assumes the erect position.

3. Man has a conscience, the expression of his moral organs; the beast has none, not possessing moral faculties.

1. The anatomical difference mentioned, the fact that man has a chin while no lower animal has, is an interesting fact, especially when considered in connection with the fact that idiots who are born such usually have retreating chins. Indeed, all the examples of this class we have ever seen presented so slight a prominence of the inferior maxilla that they could scarcely be said to possess a chin. It must not be supposed, however, that it is possible to determine a person's mental capacity by the size of his chin, although the chin is undoubtedly a valuable index to character.

2. There are animals which naturally progress upon two legs only, as birds and some few other animals. Monkeys and various quadrupeds have been trained to walk upon two limbs; but in none of these instances is the erect attitude assumed. Indeed, the anatomical structure of all animals below man in the scale of being is such that the erect position is not only unnatural but impossible.

3. By far the most important distinction between man and his inferior relatives is the third difference noted, that which relates to the conscience. The old distinction that man has reason, while the beast has only instinct, will not at the present day stand the test of logical criticism. Scientific investigations have shown that the beast has reason as well as man. Indeed, it may be readily shown that man possesses instinct, though in less degree than the brute. The fact is now well established that both man and beast have both reason and instinct, reason predominating in man, and instinct in the beast. The real intellectual distinction is, as before remarked, that man has a conscience while the beast has not, being devoid of moral organs.

The objection will be offered to this view, that dogs and some other of the higher animals sometimes show a knowledge of right and wrong. This leads necessarily to the consideration of the question,—

What is Right, and What is Wrong?—Undoubtedly conscience is the recognition of right and of wrong. If we can determine what is right and what is wrong, we shall then be able to decide what conscience is. Probably no better definition for right can be framed than the simple one, "obedience to law." Wrong is manifestly the reverse. Conscience, then, involves the recognition of a law, and also the recognition of the obligation to obey that law. No

brute has the power to do this. If he possessed a sufficiently high degree of intelligence to enable him to recognize the existence of law, which he does not, he has no conscience to inform him of his duty to obey that law. It is for this reason that a brute is not morally responsible. If he possessed moral faculties, he would be morally responsible as much as is man. A man is responsible to the laws of digestion, because he has an organ of digestion. A beast is subject to the same laws, and for the same reason. Man is morally responsible because he has moral faculties. The beast cannot be morally responsible, because he does not possess moral faculties. The seeming exhibitions of knowledge of right and wrong on the part of dogs and other lower animals on careful examination will prove in every case to be prompted by hope of reward or fear of punishment, or some other similar incentive. A dog can be taught to do things very contrary to his nature by appealing to his sense of fear or some other faculty stronger than the one suppressed. There is in this no recognition of obligation to law. The brute classifies actions not as right or wrong, but as what will bring reward or pleasure and what will bring punishment or suffering. Much that passes for conscientiousness among human beings is equally distinct from the exercise of true conscience. True conscience recognizes right and wrong on their own merits without regard for consequences, either rewards or penalties.

The fact that man possesses a will does not make him morally responsible, since lower animals possess a will as well as man. Moral responsibility consists not in the power to *do* right or wrong, but in the power to discriminate between that which is lawful and that which is unlawful. No difference in kind can be shown to exist between the human will and that of brutes, the only difference being one of degree.

Thus it appears that the possession of a conscience or of a moral nature is the true mental characteristic of the human species, and not the power of thought or the possession of will. The importance of the will from a psychologic point of view is found to be far less than has generally been supposed when it is made to appear, as will be seen farther on, that desire, and not the will, is the primary incentive to action.

GENERAL ANATOMY, OR HISTOLOGY.

We must now confine our study more closely to the structure of the human body, and we shall begin where students in their study usually leave off; viz., with the minute elements of which the body is composed, the tissues. All the various vital processes upon the proper performance of which the life of each individual depends, are performed by the minute tissue elements which we are about to consider, and cannot be understood without a careful study of these elements. Hence it seems to us to be eminently philosophical to begin at the foundation in order that we may secure an accurate knowledge of the subject under investigation.

How a Human Machine is Built.—The human body may be regarded as the most marvelously constructed of all mechanisms. Its parts are far more delicate, and their mutual adjustments infinitely more accurate than those of the most perfect chronometer ever constructed. In order to understand the structure of this wonderful mechanism, let us go back to the earliest period of its existence. At this time we find the body to be but a mere speck of matter, a single cell, a delicate little mass of jelly-like protoplasm so small that a hundred or two would not measure more than an inch if arranged in a row. Under proper circumstances this little cell grows, expands, and finally subdivides into two, through the operations of the protoplasm which chiefly composes it. The same activity occasions another subdivision, making four cells of the two. Still another division produces eight cells. Thus the processes of growth and division continue until the one original cell has developed into hundreds, even thousands and millions, under the active working of the protoplasm, which is the chief component of the cells and the potent agent in their activities. Development and division still continue while a new process of folding and reduplication is set up, layers of cells being formed, groups and subgroups being set off, which develop into special systems and organs in accordance with the wants of the organism, until by and by the whole complex organism which we call man is developed. Throughout the whole process, protoplasm is the active agent, the skillful workman that builds and fashions and molds the crude material out of which human tissue is made and brought into its final delicate and wondrous harmony and beauty.

Let us now study with greater care the mode of working. The little masses of protoplasm already described are untiring workers. They also work in a great diversity of ways. For instance, a single mass of protoplasm will sometimes build a delicate wall about itself, when it becomes a true cell, being shut up in a tiny house of its own construction. The protoplasmic body may remain in its self-made prison during its whole life, and die there; or through a wonderful property it possesses it may escape from its prison cell by passing directly through the wall, and proceed to build other cells similar to the first, thus building a large number in the course of its lifetime. An army of protoplasmic bodies working in this way may in time construct a huge tree. Indeed, it is in exactly this manner that trees are built.

But protoplasm does not always operate in this way. In animals, particularly, it usually works in a different fashion. Instead of building a wall about itself, it makes fibres, tubes, bands, and a great diversity of other structures, such as are needed in a complicated mechanism like the human organism. The structures thus formed in the construction of the human body are known as *anatomical elements.* These we will now describe.

The Anatomical Elements.—Notwithstanding the great complexity of the human organism, its great variety of structure, and the wonderful diversity of function performed by its different parts, it is wholly made up of a very few simple elementary structures, not more than six or at most seven in number. These may be divided into two classes: 1. Those which possess a very low grade of life, being simply useful in supporting or holding together, or protecting more highly vitalized and more important parts; and, 2. Those possessed of a high degree of vitality, being chiefly composed of protoplasm, and upon which all the activities of the system really depend. The first class consists of the connective tissues, comprising the two varieties of fibrous tissue, adipose tissue, osseous tissue, and cartilaginous tissue; the second class comprises nervous and muscular tissue. We will now proceed to describe each of these tissue elements separately.

White Fibrous Tissue.—Fig. 9. This, the most abundant of all the anatomical elements in the body, when viewed under the microscope is found to be composed of minute fibres varying in thickness from one forty-thousandth ($\frac{1}{40,000}$), to one twelve-thousandth ($\frac{1}{12,000}$), of an inch in diameter, and of varying length. The fibres are white in color, and

wholly inelastic. White fibrous tissue constitutes the chief element of tendons, ligaments, and other parts where firmness is required. This element is also found intimately interwoven with all the other elements of the body, serving to unite them together and give firmness and solidity to the whole.

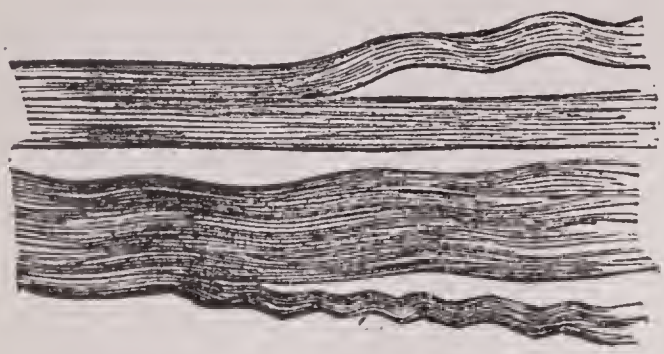


Fig. 9. White Fibrous Tissue.

White fibrous tissue possesses the curious property of being soluble in some acids. Acetic acid will dissolve its fibres and cause them to entirely disappear from view under the microscope.

Yellow Elastic Tissue.—Fig. 10. This tissue is perhaps the next most abundant element, being found in greater or less abundance in all parts of the body. It differs much from white fibrous tissue, its fibres being yellow in color, and very elastic. The fibres instead of being straight are more or less curled and branched, and are much larger than those of white fibrous tissue. Yellow elastic tissue is quite abundant in the skin and all other animal membranes, to which the high degree of elasticity of membranes is due. The *ligamentum nuchæ*, a ligament located at the back of the neck, is composed almost wholly of this tissue. In the ox and other grazing animals this ligament is greatly developed, and serves the animal a very important purpose, holding the head in position without the action of muscles when the animal is not reaching down for its food. In the giraffe this ligament is six feet in length, and possesses such a high degree of elasticity that it is said that it can be stretched to the length of twenty feet.

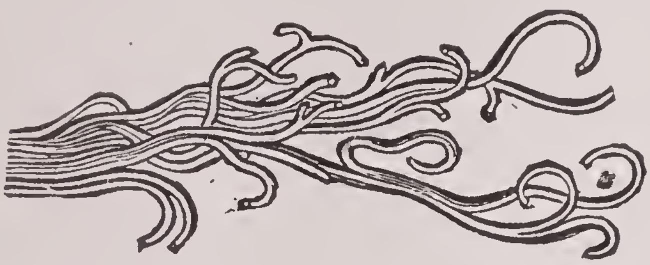


Fig. 10. Yellow Fibrous Tissue.

Connective Tissue.—Fig. 11. This tissue is not an anatomical element, being wholly made up of the two former. It constitutes a great share of the bulk of the body, forming, in fact, a framework by which the various parts are held together, and serving to bind together the several elements of which the different organs are composed. The skin and other membranes are almost wholly made up of connective tissue. The white and yellow fibres are in this compound tissue interwoven

together in such a way as to form a fine network with meshes. These interspaces are usually occupied by the fluid part of the blood, which bathes the minute elements of the body in every part, and supplies them with the needed nutriment. It is in these spaces that the lymph channels, the set of vessels which run from all parts of the body toward the center of the circulation, have their beginning. In general dropsy or œdema, these spaces are distended with serum. Cases sometimes occur in which the spaces become filled with air, as in injuries to the lungs in which the pulmonary cavity is made to communicate with the connective-tissue spaces, when by a sort of pumping action the process of respiration has been known to cause enormous distention of the whole body. Some years ago a couple of unnatural parents were arrested for the most revolting cruelty to a little girl whom they were exhibiting about the country. The child was shown as a monstrosity, its head being distended to enormous proportions. Upon investigation of the case, it was found that the child's scalp had been gradually distended to its unnatural proportions by means of inflation with air through a pipe-stem. It is a well-known practice with butchers to thus distend the connective tissue of sheep in dressing them for the market, by which means they are rendered much more attractive than they would otherwise be.

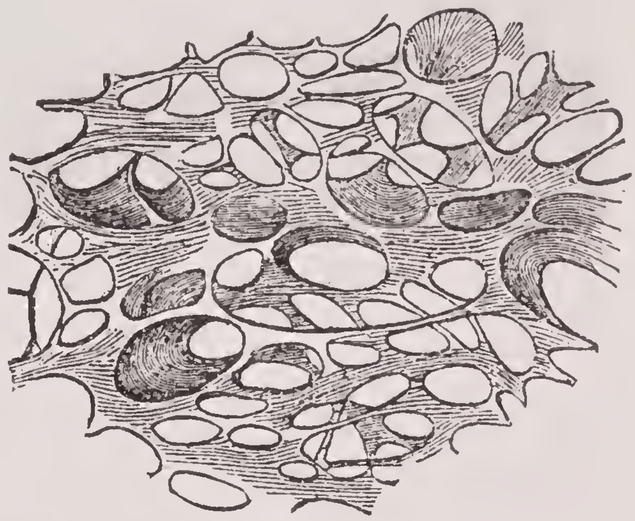


Fig. 11. Connective Tissue, showing spaces produced by drawing the fibres apart.

Adipose Tissue.—Fig. 12. This tissue really consists of connective tissue in which the spaces between the fibres have been filled with fat cells, the size of which is variable, but probably averages about one one-hundred-and-twenty-fifth ($\frac{1}{125}$) of an inch. Adipose tissue is found in greater or less quantities in nearly all parts of the organism, but particularly just beneath the skin,

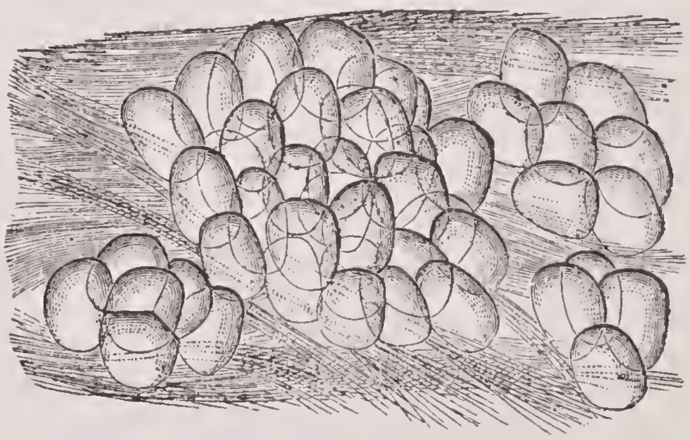


Fig. 12. Adipose Tissue, showing fat cells deposited in the connective-tissue spaces.

where a layer is deposited seemingly as a protection from cold. Adipose tissue is much more abundant in winter than in summer, being then needed much more than in the warmer seasons of the year.

Cartilage Tissue.—This tissue, in its typical form, consists of a homogeneous, structureless base in which are scattered, with a considerable degree of regularity, cavities in which are found cells which during life fill the entire cavity. The structure of this peculiar tissue will be readily seen in Fig. 13. Cartilage is chiefly found in adults at the ends of bones, where a moderate degree of elasticity with very slight sensibility to pressure is required. These properties are admirably supplied in cartilage. In early life the bones are composed of cartilage, the change from cartilage to bone taking place during the period of growth. After complete ossification has taken place, no further development can occur.

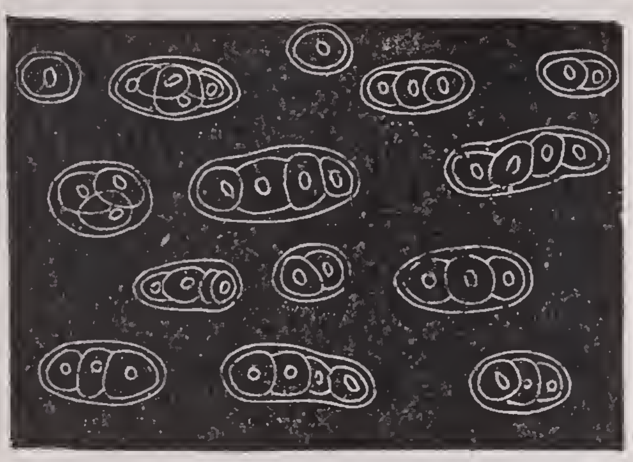


Fig. 13. Cartilage Tissue, showing the characteristic cells.

A peculiar kind of cartilage known as fibro-cartilage is found between the vertebræ, and at some other points where there is a very limited degree of motion. Cartilage is in some few instances developed in tendons and even in the skin and other tissues, where it is always more or less intimately blended with connective tissue. In old age, cartilage sometimes undergoes a process of hardening from the deposit of lime, which is known as calcification.

Osseous or Bony Tissue.—In Figs. 14 and 15 will be seen an excellent representation of the minute structure of bony tissue. The large irregular canals seen in Fig. 15, and represented by circular openings in Fig. 14, are the blood-vessels of bone, here known as *Haversian canals.* The dark spaces with the lines radiating from them are *lacunæ* and *canaliculi,* together forming the bone corpuscles. Fig. 14 shows very beautifully the admirably systematic arrangement of these corpuscles, and the manner in which they communicate with each other and with the blood channels. The dark spaces are cavities in the bone, and the small lines running out from them represent minute canals by which they are connected. Each cavity is occupied by a

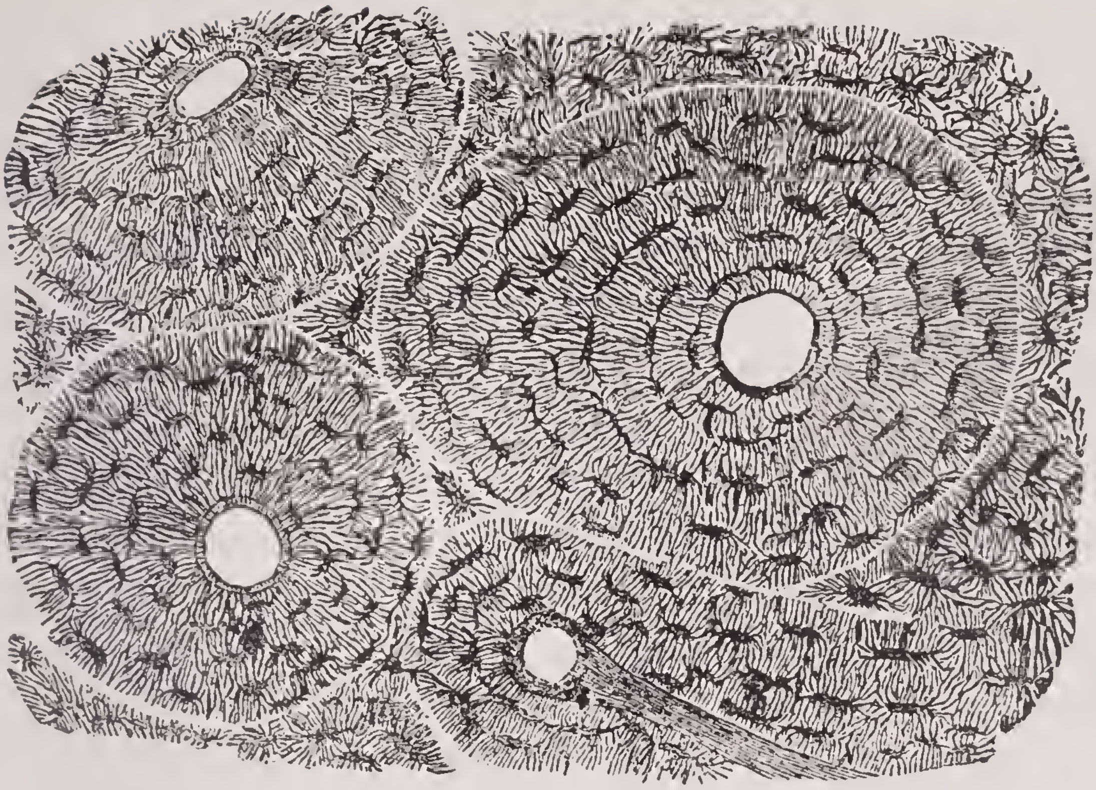


Fig. 14. Transverse section of bone as seen with the microscope.

mass of protoplasm, a cell, which puts out a number of protoplasmic fingers by which it touches other cells near by; and thus the minute creatures which inhabit these little caves in the bone are enabled to communicate with one another through all its parts. The business of these little creatures is to develop the bone and to keep it in good repair. They have charge of the bone-building business of the body, each having its particular little section of bone to look after. The portion of the tissue surrounding the cavities and canals, and forming the great bulk of the tissue, is made up of a curious compound of animal matter with various salts in a partially organized state, the chief of which are phosphate and carbonate of lime. The evidence is that they are in a state of partial organization, a condition which might be termed organic. Some eminent observers say that in very old age the protoplasmic bodies which occupy the cells of bone tissue die, the spaces being then filled with air.

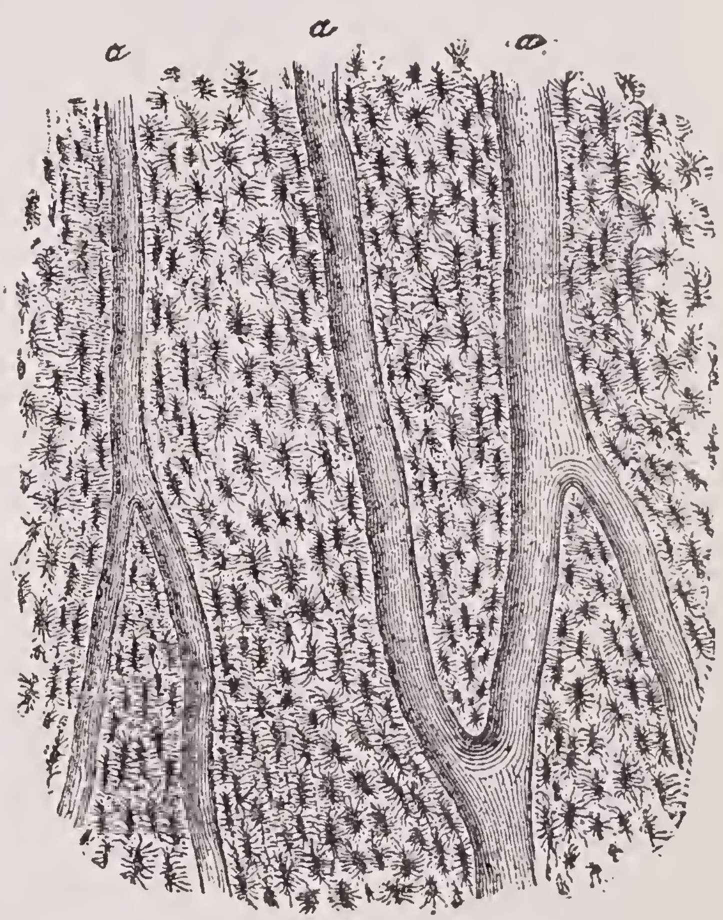


Fig. 15. Magnified view of a longitudinal section of bone; *a a a*, Haversian Canals.

Osseous tissue forms the skeleton of the body, the bony framework

upon which the soft parts are built, together with a portion of the substance of the teeth. In lower animals, bony tissue is also deposited in the skin, the white of the eye, and other soft parts. Very singularly, it also happens in some cases of disease that bony tissue is developed in the soft tissues.

Muscular Tissue.—There are two varieties of muscular tissue. One consists of long, unbranching fibres, marked by transverse lines called *striæ*, the other of short, branching, spindle-shaped fibres which are smooth or *unstriated.* Fig. 16 represents those of the first class, or *striated* muscular fibres, which compose the greater portion of the soft parts of the body, constituting the lean meat of animals. They can be easily seen with a strong microscope, and are very interesting objects of study. This variety is sometimes distinguished from the other by the difference in action, being called *voluntary* muscular tissue because it composes all muscles which are under the immediate control of the will. A striated muscular fibre consists of a tubular sheath containing the active muscular substance, which appears to be divided into minute beaded fibres, although the exact ultimate structure of these primary fibrillæ is not very well understood.

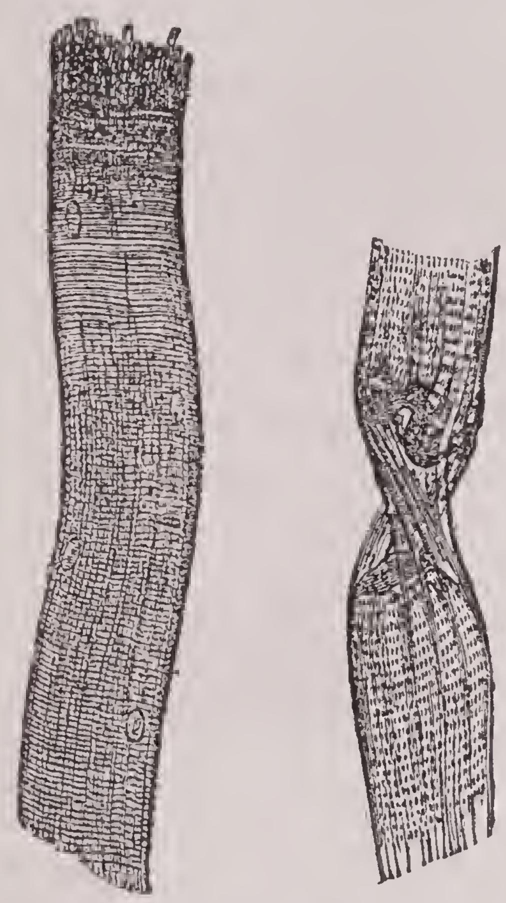


Fig. 16. Voluntary Muscular Tissue, showing smallest fibers with striæ.

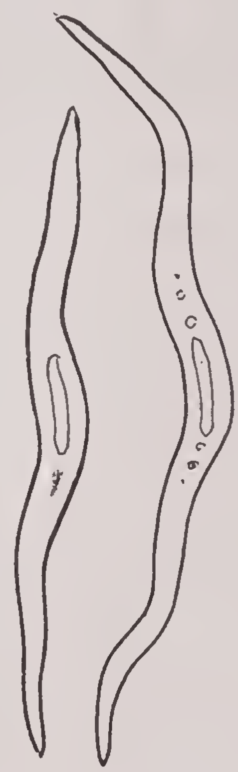


Fig. 17. Involuntary, or non-striated Muscular Fibre.

Non-striated or *involuntary* muscular fibres are found in muscular organs not under control of the will, as the gullet, the stomach, intestines, bladder, and urinary passages. The form and simple structure of this kind of tissue are sufficiently well seen in Fig. 17, so

that no further description is necessary. It should be mentioned that the heart, although an involuntary muscle, is composed of a muscular tissue peculiar to itself, its fibres in some respects resembling both voluntary and involuntary muscular fibres. This is probably owing to the physiological fact that voluntary fibres contract with rapidity and vigor, while the contraction of involuntary fibres is slow and less vigorous. However, voluntary muscles soon tire by continuous exercise, while involuntary fibres are capable of maintaining their activity for a long time. The heart admirably combines both properties.

Fig. 18. Nerve Cells, showing prolongations, or poles, three of which are prolonged to form nerve fibres.

Fig. 19. *c.* Nerve Fibre moderately magnified; *a.* Greatly magnified, showing fibrillæ; *b.* Fibrillæ magnified still more, showing beaded appearance.

Nerve Tissue.—This is by all odds the most interesting, and perhaps the most important, of all the anatomical elements. As is the case with muscular tissue, there are two varieties of nerve tissue. These are familiarly known as cells and fibres, the gross distinctions between which may be readily seen by reference to Figs. 18 and 19.

Nerve cells are irregularly shaped bodies of protoplasm, usually provided with one or more arms or projections of the same substance. In the center of the cell may be seen a nucleus, and, usually, within the nucleus another smaller center, called a nucleolus. The branching arms are termed poles. Nerve cells are found chiefly in the brain and spinal cord; but they are also found in groups known as ganglia in various parts of the body. They are the generators of nerve force, and correspond to the batteries used in telegraphy.

Nerve fibres are composed of a bundle of minute fibres, which forms the *axis-cylinder*, invested by a peculiar substance which acts as an insulator. The nerve fibrillæ are minute filaments of protoplasm, being simple prolongations of the protoplasm of nerve cells in the brain and spinal cord. These filaments are continuous from their starting-point in the nerve cells to the part of the body, near or remote, in which they terminate. Thus there is formed a complete network of protoplasmic threads through all parts of the body, connecting every minute portion of the system with the central organ, the brain, much like the network of telegraph wire which may be seen traversing the air in every direction in any large city, connecting its most distant parts with the central office.

When it is understood that all thought, feeling, sensation, and even all motion and vital action of every sort, is dependent upon nerves and nerve cells, it will be granted that we have not overstated in calling this the most important of all the tissues of the body.

Membranes.—Membranes are chiefly made up of connective tissue. They are not anatomical elements, but simple combinations of elements. A membrane consists essentially of a layer of connective tissue which forms the basis, over which are spread several layers of cells, or protoplasmic bodies, called *epithelium*. Besides the skin, which is a form of membrane, there are three other kinds of membrane, *mucous, serous,* and *synovial*. Mucous membranes line cavities which communicate directly with the outside of the body, as the mouth and the whole digestive tract, the air passages, and the urinary cavities and passages. Serous membranes line closed cavities. Synovial membranes partially line the cavities of joints. Each of these several kinds of membrane, including the skin, secretes a fluid peculiar to itself. The skin produces perspiration, or sweat, by means of the sweat glands. Mucous membrane produces mucus, from its mucous follicles. The serous membrane produces a serous fluid; and the synovial membrane secretes a fluid for the lubrication of the joints.

The cells, or epithelium, covering these various membranes, differ very considerably, and also differ on the same kind of membrane in different parts of the body. Some forms of epithelium are exceedingly curious and interesting. For example, a kind known as *ciliated* epithelium is covered with delicate hairs which are kept in constant and rapid motion during the life of the cell. A small section of mu-

cous membrane having this kind of cells when viewed under a microscope presents the appearance of a field of grain waving in the breeze. Specimens of this kind of cells can be obtained for examination from the air passage or from the mouth of a frog, or, better, from what is termed "the beard" of a live oyster. Fig. 20 exhibits a number of varieties of epithelial cells.

Fig. 20. Specimens of Epithelial Cells of various sorts.

As the other tissues will receive ample consideration in connection with the description of the various organs in which they are found, we will not devote more space here to the subject of general anatomy, or histology, although it is a subject of great interest.

A General View of the Human Mechanism.—Having now viewed quite minutely the anatomical elements, the brick and mortar, so to speak, of the human body, let us briefly glance at this wonderful machine as a whole, before beginning a minute description of its several organs and their functions, as by this means we shall be better able to understand the relations of each part to the whole.

The human body may be considered as a machine constructed for the purpose of thinking, feeling, and acting; at any rate, these three things comprise all the capabilities of any human being. For the performance of these functions there is necessary,—

1. A set of organs capable of thinking and feeling. This we have in the *nervous system.* Certain of the nerve cells of the brain are undoubtedly endowed with the power to think. Their activity is thought. By means of certain accessory apparatus, the organs of sense, which comprise hearing, sight, taste, smell, touch, the sense of weight and the power to distinguish temperature, the thought or mind cells of the brain are able to take cognizance of external things; in other words, to feel or receive sensations. Through the almost infinite ramifications of the delicate nerve fibrillæ already described, all parts of the body are not only made tributary to the brain, but are brought under its domination.

2. There is needed a special set of organs by means of which motions of various sorts can be executed. This want is exactly supplied by the *muscular system,* acting in connection with the bones

and the nervous system. The bones serve as points of attachment for the muscles, by which they are employed as levers. The nervous system furnishes the impulse, and the muscles execute the order by contracting in accordance with the directions given to them through the nerve telegraphic communications from the brain.

If the human machine operated without friction or wear, this would be all we should require to perform all the necessary functions of individual life; but every thought, every sensation, every motion or muscular action, is at the expense of tissue. The vital machinery wears and wastes as do all other mechanisms. This necessitates a constant supply of fresh material, and a system of repair. The new material is supplied by the *circulatory apparatus,* which comprises the heart and the blood-vessels, the chief object of which is to distribute the material for repairs wherever it may be needed throughout the system, the nutrient fluid, the blood, being itself replenished through the *digestive apparatus,* which is specially designed for the purpose. Unlike any machine of human invention or construction, this wonderful mechanism possesses the power, within certain limits, to repair itself and keep its own parts in order. Each particular part possesses the power to repair and renovate itself; and so long as this power remains intact, provided the proper amount of new material is furnished, so long will the machine continue to run.

But our machine is not yet wholly complete. The waste products which result from the wear and tear of the tissues in action must be disposed of. If allowed to remain in the system, they would very soon obstruct the delicate machinery so that proper action would be impossible, and activity would speedily cease. This necessitates a special set of cleansing organs to dispose of waste and worn-out particles. This want is supplied in the *eliminative system,* comprising the lungs, which throw off a pound of gaseous filth every day, the skin, which is almost equally active, the kidneys, the liver, and the bowels. These five active organs are constantly at work removing from the body substances that are of no use, and which will obstruct and retard vital action if retained. The human machine clears itself of obstructions. The blood also plays an important part in this work, since in addition to distributing nutriment where needed, it bathes and washes every tissue free from the obstructions which may have accumulated in or about it and hurries them off to the proper organ which is designed to eliminate or remove them.

As a certain temperature is necessary for the perfect action of this delicate mechanism, nature has so planned that all the various processes named shall result in the production of animal heat, so that this want is supplied at the least possible expense to the vital economy. As uniformity of temperature is also necessary for the proper performance of the various bodily functions, special means are provided by which a deficient supply of heat may be economized and a superabundance rapidly dispersed so as to protect the body from extremes.

So far as the individual man is concerned, the mechanism is now complete; but as the machine ultimately wears out, it is important that there should be some means provided for the perpetuation of the race. This necessity is met by the *reproductive apparatus,* by which new individuals, possessing essentially the same qualities and capable of performing the same functions, may be produced. As we shall elsewhere see, this is one of the most remarkable of all the bodily functions. Indeed, the mysteries of generation are as much beyond the power of the human mind to solve as are the problems which cluster about the origin of all things. In his reproductive function, man approaches nearest to the Creator, though in this he only uses a power delegated to him by the Creator in common with all other living things.

Thus we have complete, in every detail, this marvelous human machine, which stands as an unanswerable argument against all the sophistry that can be invented to sustain atheism, establishing beyond the possibility of cavil that there must have been at some time at work an intelligent power as much superior to the highest type of human power and intellect as this delicate mechanism is above the most ingenious piece of workmanship the most skilled mechanic has ever produced.

Having taken a general survey of the human system, its various systems of organs and their general functions, let us now look a little more carefully into the details of structure and function, so that by a thorough understanding of the nature of the various parts and organs of the body we may be the better able to understand what means are necessary to preserve them in health and to cure and prevent disease. Our attention is naturally directed to the bones, which, as we have already seen, constitute the framework of the body.

THE BONES.

Although the bones are the firmest parts of the system, they are not, as many suppose, possessed of a very small degree of life. Mere lifeless sticks would come far short of performing the functions of bones. While not as highly vitalized as some of the more rapidly changing tissues, they possess sufficient vital activity to enable them to perform their functions and to repair injuries which may occur. All the bones of the body taken together form the skeleton, for a representation of which see Fig. 21 or PLATE I.

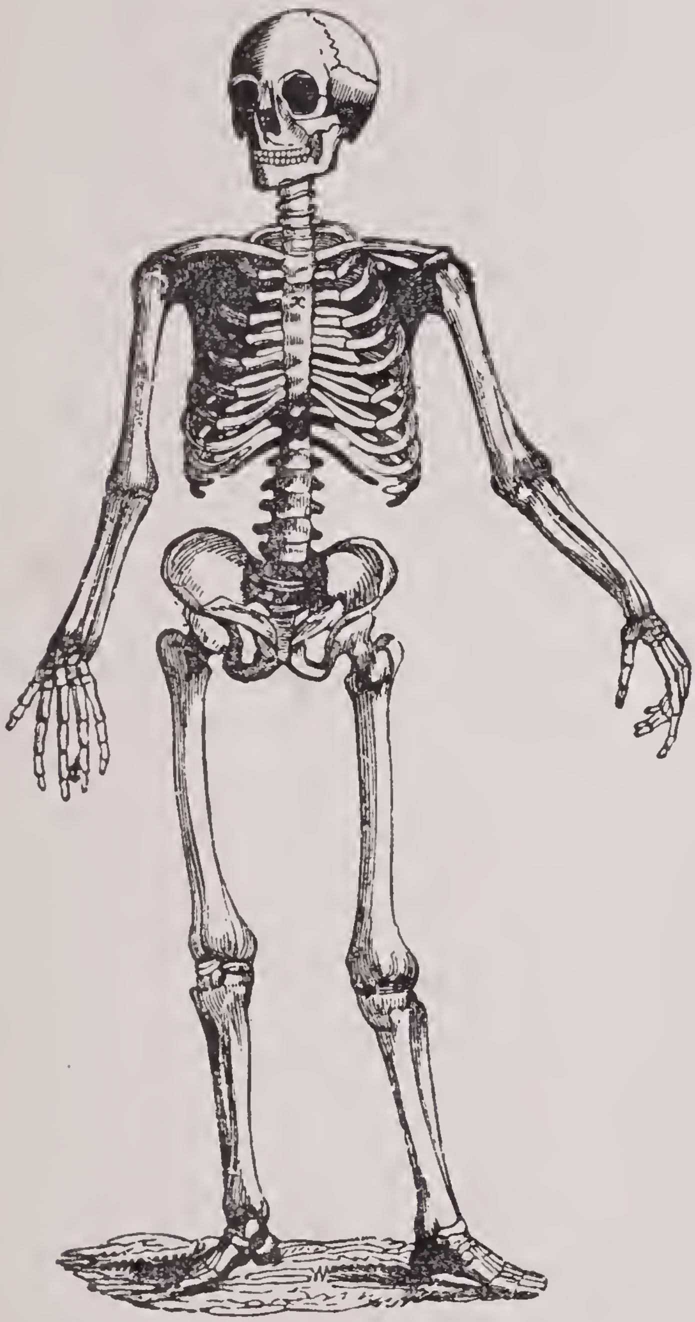


Fig. 21. The Skeleton.

Structure of Bones.—Bones are made up of a peculiar structure, which has been already described. The osseous tissue proper is covered over with a tough membrane called the *periosteum*, and commonly known as the whit-leather. Fig. 22. This membrane supplies blood-vessels to the bone, and it is from it that the bone grows. Bones are classified according to their form into long, short, flat, and irregular. Long bones are hollow, having a canal running through a greater or lesser portion of their length, which is called the *medullary canal*. This canal is lined with a membrane similar to the periosteum.

Fig. 22. Portion of a long bone, showing the periosteum slit up and separated from the bone.

called the *endosteum,* and is filled with medullary substance, which consists of blood-vessels, nerves, fat, and connective tissue. The shaft of long bones is composed of a dense, firm structure, called *compact* tissue, while the expanded ends are chiefly made up of a looser structure, known as *cancellous* tissue. See Fig. 23. Short, flat, and irregular bones are composed of a shell of compact tissue, the interior being spongy in character.

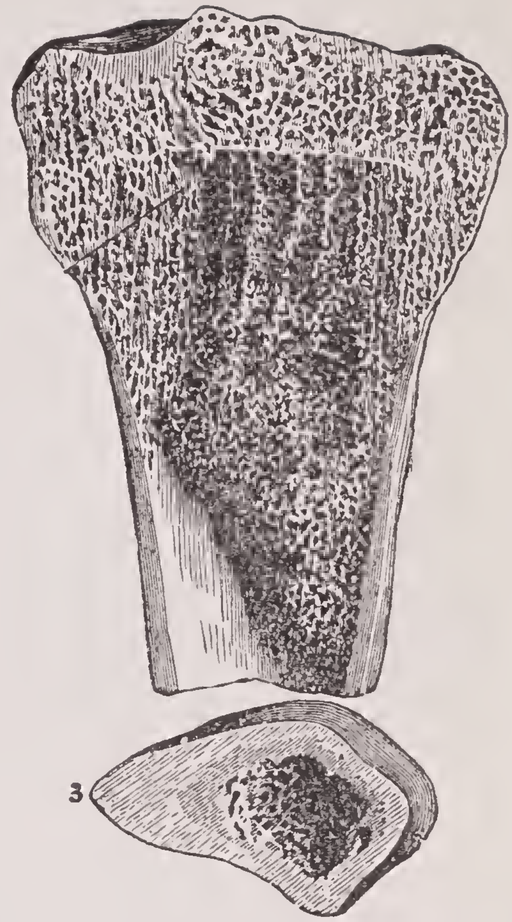


Fig. 23. The upper part of the cut shows a longitudinal section of the large end of a bone. At 3 is to be seen a transverse section of the shaft, showing the medullary canal.

The periosteum and the medullary substance, or marrow, of bone are very important portions of these organs, since injury to either of these parts is quite certain to be followed by death of the bone on account of interference with its nutrition.

The Joints.—The points at which bones come together are called articulations, or joints. The parts which enter into the formation of joints, in addition to the bones, are cartilage, synovial membrane, and ligaments. Wherever bones come in contact with any degree of motion, the surfaces of contact are covered with a dense, elastic, non-sensitive substance known as cartilage. In order that the bones shall be held together in proper position, they are bound by firm bands of fibrous tissue, called ligaments, which are so arranged as to secure firmness without interfering with the necessary movements of the joint. In order to provide for the maintenance of the joint in a healthy condition, a means is furnished for lubricating the articulating surfaces and thus lessening friction. The lubricating material is known as synovia, and is furnished by the synovial membrane, with which every joint is provided for this purpose.

Varieties of Joints.—A number of different kinds of joints are illustrated in the human body, the most important of which are, the *hinge* joint, illustrated by the knee, the elbow, the fingers and toes; the *ball-and-socket* joint, of which the hip and shoulder joints are examples; and the *gliding* or *planiform* joint, in which one flat surface glides over another, as in the short bones of the wrist and the ankle.

Divisions of the Skeleton.—The skeleton is divided into three parts; viz., the head, the trunk, and the extremities. The number of

bones contained in each of these portions is as follows: The head, 22; the trunk, 52; the extremities, upper and lower, 126; making 200, the whole number of bones in the body.

BONES OF THE HEAD.

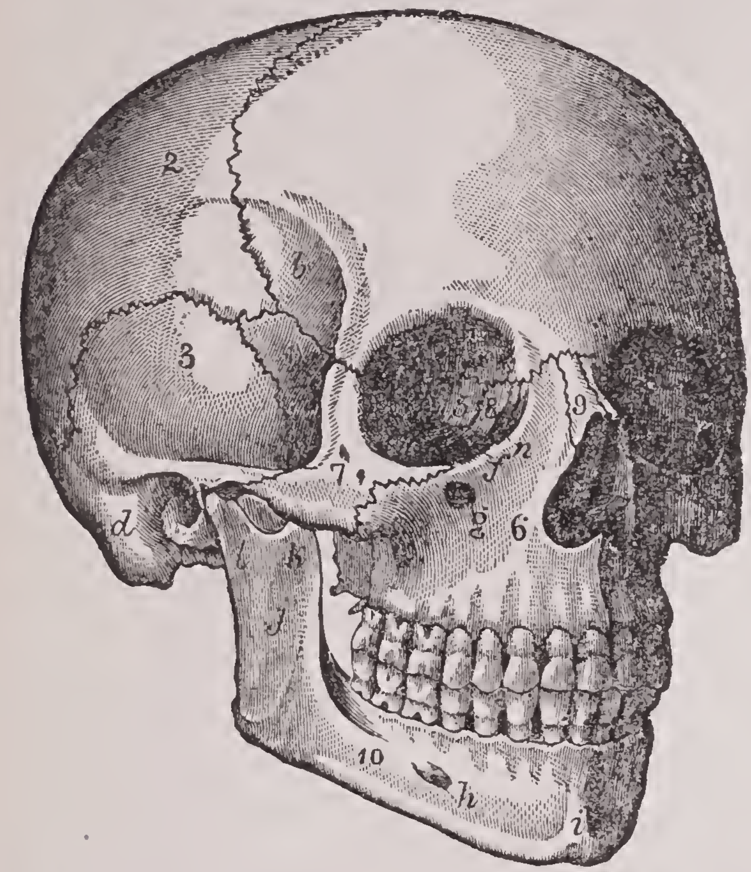


Fig. 24. The Skull, showing the sutures, or points of union between the several bones.

Fig. 25. The Skull, with the bones separated so as to show their shape. 1. Frontal; 2. Parietal; 3. Occipital; 4. Temporal; 5. Nasal; 6. Malar; 7. Superior Maxilla; 8. Lachrymal; 9. Inferior Maxilla. Several bones are not shown.

Of the twenty-two bones forming the head, eight enter into the structure of the skull, or *cranium*, the remaining fourteen forming the face.

The Skull.—The cavity of the skull is designed for the reception and protection of the brain, a purpose to which it is most admirably adapted both by its general shape and its minute structure. The bones of the skull each consist of two plates of compact tissue connected together by a layer of very spongy tissue called *diploe.* See Fig. 26. This gives to the skull a degree of elasticity which it could not otherwise possess, thus protecting it from fracture, and also serves to deaden the effect of blows upon the head before the force has been transmitted to the delicate brain beneath. The bones of the skull are firmly joined together by means of *sutures,* which in infancy allow of some degree of motion; but as the skull assumes its full size, the sutures become knit together so firmly

as to preclude the possibility of motion. It is owing to this fact that different nations are enabled by different modes of dressing the head to cause it to assume different shapes. For example, certain Indian tribes, by applying a flat surface to the forehead and binding it firmly in place in early infancy, are enabled to produce a permanent flattening of the forehead. A class of the natives of India are noted for the peculiar cone-shaped form of the head which they produce by a similar process.

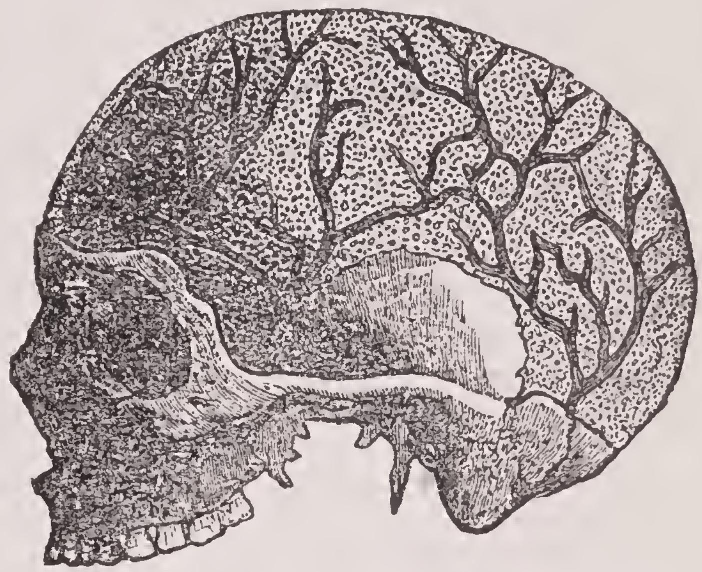


Fig. 26. The Skull with the outer plate removed, showing the diploe and the channels for blood-vessels.

A number of openings are found in the skull, the largest of which, called the *foramen magnum* from its large size, is located in the inferior and back part, and affords a passage for the spinal cord. The numerous other smaller openings are for the passage of blood-vessels and nerves.

The interior of the cranial cavity presents many ridges, depressions, and processes, which correspond with the uneven surface of the brain, which with its membranes exactly fills the cavity.

The names and location of the eight bones forming the skull are, the *occipital,* which forms the whole posterior portion ; the two *parietal,* which chiefly form the sides and upper portion ; the two *temporal,* situated low down upon the sides ; the *frontal,* forming the whole front portion of the skull ; the *ethmoid,* which is placed in the lower part of the skull near the root of the nose ; and the *sphenoid,* which joins all the other bones together at the base. At birth it is usually the case that the frontal bone is in two parts, it being always formed in this way, the two halves being afterward joined together very early in life. At birth, ossification of the bones of the cranium has not fully taken place, the deficiency being very apparent at two points, one at the anterior portion of the head and the other at the upper and back part. At these points the covering of the brain is so thin that it yields readily to pressure, and the beating of the arteries can be easily felt. On this account, these points are commonly termed "soft spots." The medical term is *fontanelles.* As ossification progresses rapidly after birth, the fontanelles are soon closed up.

The Bones of the Face.—The fourteen bones which form the face are named as follows: two *nasal,* two *lachrymal,* two *malar* or cheek-bones, two *upper maxillary,* two *palate,* two *turbinated* or spongy bones of the nose, the *vomer,* and the *lower maxillary* or under jaw-bone.

The two *nasal* bones form the upper part or bridge of the nose, joining the frontal bone of the skull. They are small bones, and are lengthened out upon the sides of the nose by cartilage.

The two *lachrymal* bones are so called because they contain a small canal which conveys the tears from the eye to the nose. They are situated at the inner corners of the eyes, and join the nasal bones.

The *malar* or cheek-bones are situated at the outer and upper part of the face. In some nations, as the Tartars and North American Indians, these bones are very prominent, giving an angular appearance to the features.

The *superior maxillary* bones constitute the greater portion of the face, joining in front beneath the nose. They also form the greater portion of the roof of the mouth, and afford a place for the insertion of the sixteen upper teeth. Each of the maxillary bones has in its upper portion a cavity of considerable size which is lined with mucous membrane, and communicates with the nasal cavity through a small opening. This cavity is known as the *antrum of Highmore.* It often becomes a seat of disease through the formation of abscesses and the production of polypi or other morbid growths, which occasion very great trouble and annoyance on account of the difficulty of gaining access to the diseased part. It is supposed that the object of these cavities is to improve the quality of the voice.

The superior maxillary bones usually unite at birth or soon after, being joined by two small intervening bones called *intermaxillary,* from their position. In case the maxillary and intermaxillary bones fail to unite, a fissure is left which usually extends down through the roof of the mouth as well as through the lip, producing a deformity which from its peculiar resemblance to the lip of a hare is known as hare-lip. When the deformity exists upon both sides it is known as double hare-lip. The only remedy is a surgical operation.

The *palate* bones are small structures placed at the back part of the mouth, forming the upper part of the roof of the mouth and extending upward to aid in forming a socket for the eye.

The *turbinated* or spongy bones are located in the upper part of the

nostrils. They are very spongy in character, and by their scroll shape present an extensive surface for the nasal mucous membrane, in which are located the nerves of smell.

The *vomer* derives its name from its resemblance to a plowshare. It is a thin, flat bone, and forms the septum of the nose.

The *inferior maxillary* bone forms the lower jaw, in connection with the teeth which it carries in its upper portion. It is a somewhat V-shaped bone, the apex of the angle being in front and forming the chin. The two lateral portions after extending backward about one-half their length take a somewhat abrupt turn upward, thus forming what is called the angle of the jaw. The upper ends of the ascending portions are joined by a hinge-like articulation to the skull. The socket of the joint being rather shallow, the bone not infrequently slips out of place in violent yawning or laughing, producing dislocation. The manner of remedying this difficulty will be fully described in the proper place.

The length of the jaw gradually increases with the growth of other parts of the body, additional teeth being produced at the back part as there is room for them, so that in adult life we find sixteen full-sized teeth, whereas in childhood there are but ten small ones. The teeth are placed in sockets provided for them by the *alveolar processes.* When the teeth fall out, from disease or old age, the processes are usually absorbed. It is this which occasions the peculiar prominence of the chin noticeable in elderly persons.

The form and location of most of the bones of the face and skull will be better seen in Figs. 24 and 25 than they can be described.

The teeth will be fully described in connection with the organs of digestion.

BONES OF THE TRUNK.

The bones of the trunk consist of the *vertebræ,* the *ribs,* the *sternum,* and the *pelvis.*

The Vertebræ.—Fig. 27. These bones are twenty-four in number, and are arranged one above the other, forming a bony column called the vertebral or spinal column, which is the central axis of the body. Each vertebra (Fig. 28) is an irregularly shaped bone, the larger portion of which, called the body, is concave behind, convex in front, and nearly flat on its upper and lower surfaces. Projecting from the back side of the body is a bony arch which has at the center behind a more or less distinct prominence known as the

spine of the vertebra, or the spinous process. There are various other projections from the sides of the body and arch which serve as means for joining the vertebræ together and for the attachment of muscles. There is also noticeable a notch at the junction of the body and the arch on either side of the vertebræ, both above and below in most cases. When the vertebræ are arranged one above another in the spinal column, the bodies form a bony pillar, while the arches, being placed one above another, form a bony canal for the spinal cord. The notches before mentioned, being also superimposed one above another, form lateral openings through which the spinal nerves and blood-vessels may pass. Between each two vertebræ are placed discs of *fibro-cartilage*, the use of which will be seen farther on.

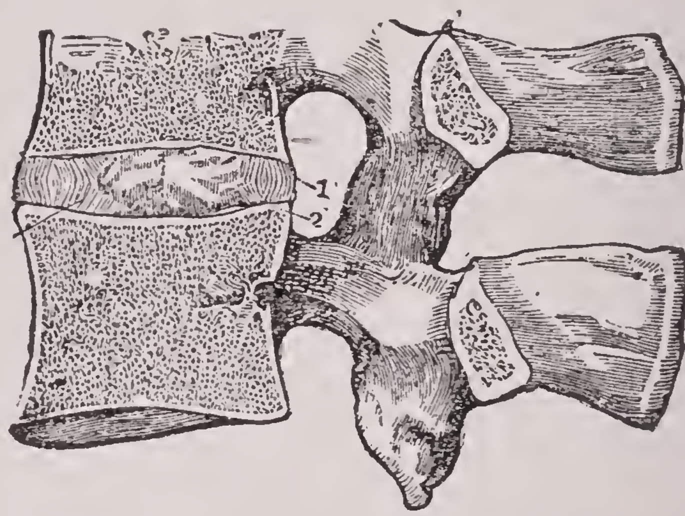


Fig. 28. A vertical section of two contiguous Vertebræ, showing the spongy structure of the bodies, and the Fibro-Cartilage between them.

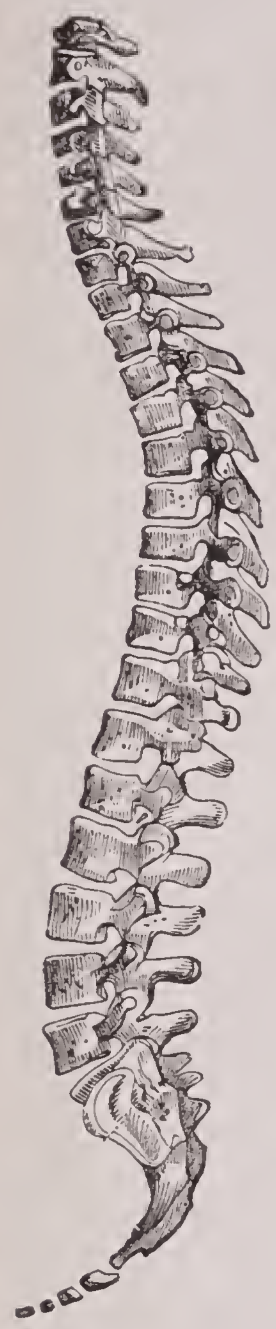


Fig. 27. The spinal or vertebral column.

The vertebræ of the spinal column are divided into three portions: the *cervical*, or neck portion, comprising the first seven, which form the neck, supporting the head; the *dorsal*, or back portion, which are connected with the ribs, consisting of twelve vertebræ; and the *lumbar* portion, the remaining five, comprising the vertebræ of the loins.

Each of these three classes of vertebræ possesses certain special characteristics by which they may be known; but as most of these are of merely anatomical interest, we will not stop to consider them, only noticing the interesting peculiarities of the first two vertebræ of the neck, those next the skull. The first vertebra, called the *atlas*

(Fig. 29), instead of having a body, arch, and various processes, is simply a ring of bone made to fit the under part of the head, surrounding the foramen magnum. The articulation of this bone with the head is such as to admit of free motion backward and forward, hinge-fashion, but no lateral or rotary motion. The second vertebra is equally peculiar, having upon one side a large tooth-like prominence which fits into one side of the ring-shaped bone above, and provides for lateral or rotating motion of the head. This tooth-like prominence, known as the *odontoid process*, is kept in place, and prevented from injuring the delicate spinal cord which passes close beside it, by means of ligaments which inclose it and hold it firmly in position.

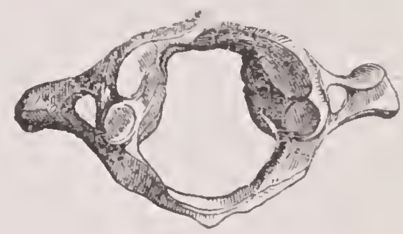


Fig. 29. The first vertebra, called the Atlas.

Another peculiarity worthy of mention is the fact that the arches of the cervical vertebræ being larger than in other parts, the spinal canal is larger in the neck than in any other part of its length. This is undoubtedly a wise provision of nature to allow of the greatest possible freedom of motion without injury to the delicate structures within.

The skull itself may be considered as simply the expanded upper extremity of the spinal column, representing three or four vertebræ which have been consolidated and greatly modified.

The Thorax.—This is a bony cavity formed by the spinal column behind, the sternum in front, and the ribs at the sides. It contains the lungs, heart, great blood-vessels, nerves, and other important organs. Having already described the vertebræ, we will now notice

The Ribs.—These bones are twelve in number on each side. Occasionally there are found thirteen, instead of twelve, and sometimes there are but eleven. The ribs are joined, behind, to the sides of the vertebræ in such a manner as to allow a slight hinge motion. In front they are not united directly to any bone, but by means of an intervening piece of cartilage they are joined to the sternum. The first seven ribs, being united by separate cartilages, are called *true* ribs, while the last five, being joined to a single cartilage which unites them to the sternum, are called *false* ribs. The last one or two ribs, being sometimes not united to the sternum at all, are denominated *floating* ribs.

Along the lower and inner border of the ribs runs a groove in

which are placed the nerves and blood-vessels of the chest walls, which are thus shielded from injury. The two edges of this groove serve as points of attachment for the two sets of muscles which fill the spaces between the ribs.

The Sternum.—This bone, commonly called the breast-bone, is really made up of four separate parts, three of which are bony, being joined together by cartilage, the fourth and lower part being cartilaginous, and known as the *xiphoid* or *ensiform* cartilage. The sternum receives upon either side the cartilages of the seven upper ribs and the conjoined cartilage of the false ribs, together with the inner ends of the collar-bone, or clavicle. The object of the sternum is to brace and strengthen the ribs and clavicles, and help to inclose the chest.

We should mention that the ensiform cartilage is very variable in its form, sometimes curving outward abruptly, causing a considerable prominence, and at other times curving inward. We have frequently been consulted by persons possessing some peculiarity of this organ who had been made to believe by quacks that they were suffering with some very severe malady. Not long ago we received a letter from a young lady, a former patient, who was in great distress, having been told by a physician whom she had consulted, or a man who called himself a physician and had practiced on the credulity of the people for many years, that she was suffering with cancer, and that she should by all means visit a surgeon at once and have the malignant growth removed. Suspecting that there was some blunder in the matter, we advised the young lady to visit us before having any operation performed, which she accordingly did; and greatly to her relief we were enabled to inform her that no operation was required. The ignorant doctor had mistaken an unusually prominent ensiform cartilage for a cancer, probably considering his diagnosis confirmed by the fact that there was extreme tenderness just beneath the end of the sternum, due to abnormal sensibility of the stomach, the patient suffering from painful dyspepsia. Having met in practice one or two similar cases, we deem it worth while to call attention to this source of error.

The Pelvis.—This portion of the trunk is situated at its base, constituting the point of junction of the lower extremities with the trunk. It is composed of four bones: the *sacrum*, a wedge-shaped bone behind; the *ossa innominata*, two bones upon the sides; and the *coccyx*

below. These four bones are so shaped and joined together as to form a sort of basin by which are supported the upper soft parts of the body, particularly the abdominal organs. The several bones are joined together so firmly that scarcely any degree of motion is possible, especially in the adult. In early childhood each of the several bones named is made up of several separate portions, which are usually described in the anatomies, but which have no special practical interest, and so need not be noticed here except in a general way. Upon the back side of the sacrum is found an incomplete canal which is a continuation of the spinal canal and is occupied by the spinal column, which spreads out upon the lower portion of the bone in a peculiar manner that has given it the name of *cauda equina,* from a fancied resemblance to the tail of a horse. Through large openings in the sacrum the spinal nerves pass forward to supply important organs within the pelvis and the anterior portions of the lower extremities.

At the outer and inferior part of the *os innominatum*, at the point of junction of the three original portions of the bone, is found a deep socket called the *acetabalum* from its resemblance to an ancient Roman vinegar cup. This deep pocket is for the reception of the head of the femur, the bone of the thigh, by which is formed the hip joint. In life the socket is further deepened and strengthened by a rim of cartilage which surmounts its edge, as also by a strong band called the capsular ligament which surrounds the socket and the head of the bone, being attached to each, an arrangement which also exists in most other joints.

Upon the lower side of the two hip bones are broad prominences which support the weight of the body in sitting.

The female pelvis differs from that of the male in being larger, smoother, and less curved. This difference is so marked that it is an important means of distinguishing between male and female skeletons.

The form and position of the pelvis are well shown in the view of the skeleton given in PLATE I.

The Hyoid Bone.—This little bone, though situated so near the head as to be hardly included in the bones of the trunk, is yet of sufficient importance to require mention and description, and may as well be noticed here as elsewhere. It is the bone of the tongue, to which it is attached, and is not connected with any other bone. It is shaped some like a horseshoe, and is situated about an inch below the chin, between the root of the tongue and the upper part of the larynx. It carries the epiglottis, the cartilaginous valve which guards the entrance to the windpipe.

It also forms the center of attachment for the muscles which move the tongue and throat.

BONES OF THE UPPER EXTREMITIES.

The bones of each superior extremity consist of the *scapula, clavicle, humerus, ulna, radius,* eight wrist or *carpal* bones, five hand or *metacarpal* bones, and fourteen *phalanges* or finger bones, making thirty-two in all.

The Scapula.—This is an irregular flat bone of triangular shape, situated at the posterior part of the shoulder, forming what is commonly known as the shoulder-blade. Crossing the upper part of the bone is a sharp prominence known as the spine, which passes forward and terminates in a beak-shaped projection which overhangs the shoulder joint; beneath this is a shallow depression known as the *glenoid fossa,* which receives the head of the arm bone in the formation of the shoulder joint. The scapula is not joined either by articulation or by ligaments to any of the other bones of the trunk, as it is designed to allow to the shoulder joint the greatest possible freedom of motion, being attached to the trunk by strong muscles which hold it in place with sufficient firmness to give all needed strength to the joint.

The Clavicle.—This bone, commonly known as the collar-bone, is shaped almost exactly like the italic letter *f*. It is attached at its inner extremity to the breast-bone, and by its outer to the great prominence of the scapula. Its object is to brace the shoulders apart and thus add to the strength of the upper extremities. The clavicle is found in but few quadrupeds, but is largely developed in birds for the same reason that it is present in man. This bone is frequently broken, but as the parts cannot be very greatly displaced, the fractured ends usually unite with little difficulty and only slight deformity.

The Arm.—The bone of the arm proper is the *humerus,* which extends from the shoulder to the elbow, of both of which joints it forms a part. It has a straight shaft and rounded extremities which are protected by cartilage in the manner common to all bones entering into freely acting joints. The lower end of the bone presents a notch at its inner side through which passes an important nerve which is distributed to the inner side of the hand. It is this nerve which is hit when a person causes tingling sensations in the little finger by striking the elbow against a sharp corner. In common parlance this part is called the funny or crazy bone, though, as just seen, it is not a bone at all, but a nerve. By

placing the end of the thumb in this notch and pressing hard it is possible to produce the peculiar sensation at any time.

The Fore-Arm.—The fore-arm is composed of two bones, the *ulna* and the *radius.* The first-mentioned of these is the longer of the two, and forms with the humerus the principal part of the elbow joint, extending from the elbow down to the wrist on the little-finger side of the arm. It has but a slight articulation with the wrist.

The *radius* has a large articulating surface at the wrist and a very small one at the elbow. The two bones are united their whole length by a strong ligament. The upper end of the radius rolls in a notch upon the side of the ulna, its end resting against the lower end of the humerus.

The Hand.—The remaining bones of the upper extremity are included in the hand, which is divided into three portions: the *carpus,* or wrist; the *metacarpus,* the portion between the wrist and the fingers; and the fingers, or *phalanges.*

The *carpus,* or wrist, is composed of eight small bones arranged in two rows, possessing smooth articular surfaces, which allows of great freedom of motion in a great variety of directions.

The *metacarpus* consists of five bones, which join the digits to the wrist. Their motion is quite limited.

The digits consist of four fingers and a thumb. The fingers have each three phalanges, but the thumb has only two. Some, however, consider that there are but four metacarpal bones, which would allow the thumb three phalanges like the other digits.

The finger joints are so constructed that they are capable of not only a hinge-motion, but also a slight degree of rotary motion, which gives to the hand great suppleness and diversity of action.

THE INFERIOR EXTREMITIES.

The lower extremities comprise thirty bones, which will be described in their order.

The Thigh.—The *femur,* or thigh bone, is the largest and longest of all the bones in the body. It presents at its upper end a remarkable prominence called its head, by which it forms, with the acetabulum of the os innominatum, the hip joint. Its lower end is greatly expanded to form the knee joint, the most extensive articulation in the body.

The Leg.—The leg, like the fore-arm, is made up of two bones. The larger of these, the *tibia,* is the principal bone of the leg, forming

the chief part in the leg portion of both the knee and the ankle joints, its companion bone, the *fibula,* taking but little part in either. The latter bone is a long, slim structure, placed beside the tibia upon the outer part of the leg. Its lower end forms the outer ankle. The two bones are firmly united throughout their whole length by a strong ligament.

A third small bone is found in the tendon of one of the large muscles of the leg which passes over the front portion of the knee; this is termed the *patella,* or knee-cap. It exactly fits upon and protects the front side of the knee joint, which would otherwise be exposed to injury.

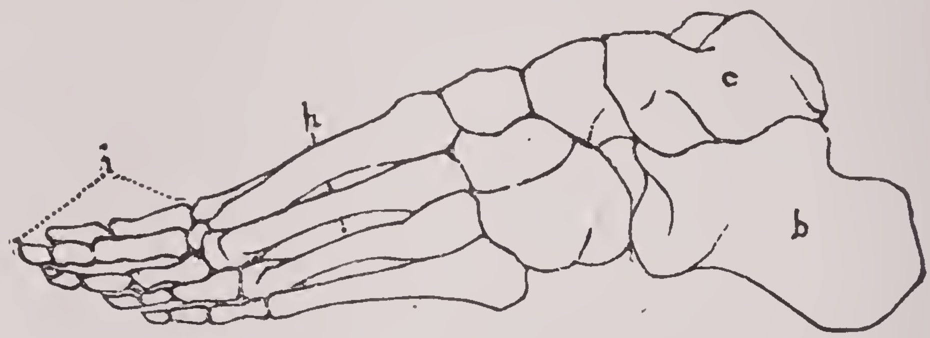


Fig. 30. Outline of the bones of the foot, showing at *c*, the *Astragalus*; *b*, the *Os Calcis*, or heel bone; *h*, the *Tarsus*; and *i*, the *Phalanges* of the toes.

The Foot.—Fig. 30. Like the hand, the foot is divided into three parts,—the ankle, instep, or *tarsus,* the *metatarsus,* and the digits or toes.

The *tarsus* is made up of seven bones corresponding to the eight bones of the wrist. One of these, the *astragalus,* supports the lower end of the tibia; another, known as the *os calcis,* forms the heel and receives the attachment of the *tendo-Achilles,* the strongest tendon in the body. All are so firmly bound together that the ankle is strong enough to sustain the whole weight of the body, notwithstanding the great number of separate bones which enter into its formation.

The *metatarsus* consists of five bones closely resembling the bones of the hand, and answering the same purpose.

The digits are five in number, each, except the great toe, having three phalanges, the latter having but two, as in the case of the thumb.

The peculiar manner in which the bones of the foot are united is a matter worthy of attention. Instead of being joined together on the same plane, they are so united as to form an arch from every point of view, both laterally and longitudinally. This arrangement greatly adds to the strength of the foot, and gives it an elasticity which protects other parts of the body from sudden jars and shocks.

The general shape and mutual relation of the bones of both extrem-

ities can be readily seen by reference to the view of the skeleton given in PLATE I.

Sesamoid Bones.—In various parts of the body where tendons pass over joints with considerable friction, small bones are often formed in the tendons, which from their resemblance to the seeds of the sesamum are termed *sesamoid* bones. The patellæ are bones of this class. Other sesamoid bones are often found in the feet and hands.

Wormian Bones.—Extra bones are sometimes formed in the cranium for the purpose of filling up a deficiency between contiguous bones. In some skulls large numbers of these bones may be found, varying in size from that of half a pea to the size of a half-dollar. These are called *wormian* bones.

Bones of the Ear.—Fig. 31. The list of bones is not complete

Fig. 31. Bones of the ear. *a. Malleus*, or mallet; *b. Incus*, or anvil; *c. Stapes*, or stirrup.

without the eight minute *ossicles* which help to form the apparatus for hearing. These we shall not describe in this connection, however, as their full description more properly belongs to the special anatomy of the ear, which see.

PHYSIOLOGY OF THE BONES.

As the particular uses of the different bones of the body have already been noticed in connection with their description, we need now concern ourselves only in relation to the general functions of the bones and the uses of special groups. The functions of bones may be said to be support, protection, and motion. Each of these functions we will now examine more particularly.

Support.—As a whole, the skeleton forms the framework of the entire body. Upon its firmness depends that of the softer parts which are built upon it, the muscles, nerves, membranes, and other tissues. Without the skeleton, the other tissues would fall limp, into inextricable

confusion. By means of the skeleton, the head is held erect, and the limbs supported in proper position, giving them efficiency and symmetry.

Protection.—Equally striking is the dependence of numerous parts of the body upon the skeleton for protection from external injury. Of this we have many examples. The skull is admirably adapted to the protection of the brain, the most delicate of all the vital tissues, being a bony cell, well arched to secure the greatest possible strength to resist external violence, and composed of two walls with a peculiar arrangement of tissue between especially calculated to deaden the effect of blows applied to the head by accident or design.

Fig. 32. Designed to show how the jar of walking is prevented from reaching the brain, by means of the curves of the body.

The head is still further protected by the peculiar curves of the spinal column, upon which it rests. This will be best understood by reference to Fig. 32, by which it will be seen that blows received from below, as in jumping, or even in walking upon a hard surface, are little felt by the head, since the various curves conduct away the lines of force and thus prevent much from reaching the head.

Still another means of protection is provided for the delicate brain, as if to secure it against the possibility of injury, in the fibro-cartilaginous cushions placed between the vertebræ. See Fig. 28. The elasticity of these discs of cartilage causes them to yield to pressure whether it be slowly or suddenly applied, and thus the brain is protected from the full force of concussions which otherwise might seriously injure. Even the slight concussions constantly occurring when one is walking over an uneven surface would, without this provision, undoubtedly occasion serious injury to the brain and the delicate organs connected with it. The amount of this kind of action is better appreciated by reference to the well-known fact that people who are much upon their feet during the day, especially those who are traveling about over

uneven surfaces, diminish very appreciably in height between morning and evening. Most persons vary an inch in height, and instances have been noted in which persons have lost more than two inches in height through vigorous and prolonged exercise. This is caused by the thinning of the cartilage discs from the prolonged pressure to which they are subjected. In elderly people the same thinning takes place, permanently diminishing their stature.

The spinal cord is protected by the bony canal formed by the rings of the several vertebræ composing the spinal column. The enlargement of this canal in the cervical portion, where it is much larger than the cord, is a marked instance of nature's fine adaptation of means to ends. The neck is designed to be turned in every direction freely; but this freedom of motion would disturb the function of the spinal cord except for the arrangement mentioned.

Another example of protection is seen in the thorax, which is a bony cage in which are encased the lungs, heart, great blood-vessels, important nerves, and several other important organs.

The pelvis also protects within its wide-spreading arch several important vital organs.

Throughout the body, as a rule, the large blood-vessels and most important nerve trunks are protected by their position upon the inner and under sides of the bones near which they run.

Motion.—The bones are the passive agents in the production of motion. The muscles, being excited to action by the nerves, employ the bones as levers. In walking, the body is, by means of the muscles acting on the bones, pried about from place to place. It is a curious fact that nearly all of the simple kinds of mechanical appliances are utilized in the production of motion; but as this subject will be dwelt upon at much greater length in connection with the study of the muscles, we will devote no further space to it here.

Possible Function of the Bones.—It has been supposed by some of the most eminent physiologists that bones having a medullary canal may play an important part in the production of white blood corpuscles, it being thought that the medullary substance is capable of producing these bodies, the origin of which has been a subject of study by physiologists ever since they were first discovered in the blood. Whether the supposition is correct or not cannot be positively asserted at the present time, as there have been no conclusive investigations on the subject.

Composition of the Bones.—Bone substance is a curious compound of living matter, and matter possessing so low a grade of life that it is even doubted by some whether or not it possesses life at all. For convenience of description, it is customary to speak of the elements of bone as being organized and inorganic, the two being supposed to be intimately blended together. It is more than probable, as before intimated, that this is not a correct statement of the fact, but that bone, like all other tissues, is a living, organized structure throughout, but so exceedingly complex in its nature that its elements are easily separated from their combination.

Recollecting the real truth in the matter, we may proceed to examine the composition of bone, for convenience considering it as a mechanical compound of certain living elements with others that are not possessed of life. If a bone is placed in the fire for a short time, when taken out it will be found to have changed its nature very remarkably. First, it will be noticed that it has lost one-third of its weight; and, second, it will be observed that it has lost its strength and toughness. A slight force will break it, and it may be easily crumbled to a fine powder; yet it retains precisely its original form and general appearance.

If, instead of placing the bone in the fire, we had immersed it in a solution of muriatic acid for a few days or weeks, we should have obtained very different results. Supposing that we have done so, we find the bone still retaining its original form and appearance, but upon weighing it we discover that it has lost two-thirds of its weight. Its nature has also changed; for instead of being firm and inflexible, it is now so flexible that, if a rib or a fibula, it may be tied into a knot. Fig. 33.

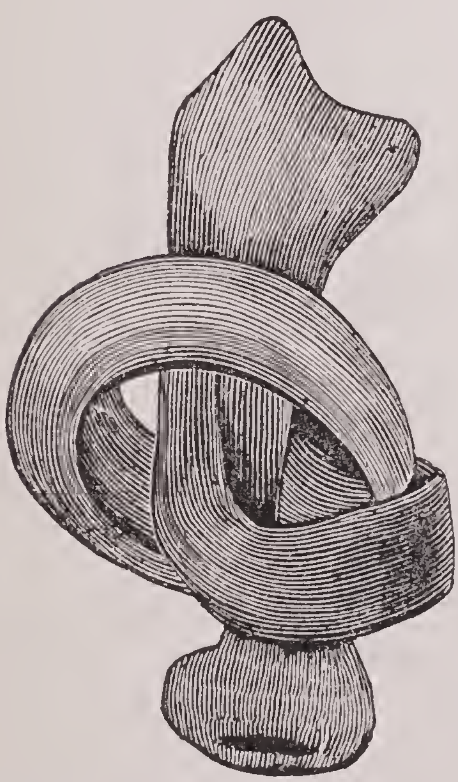


Fig. 33. A long bone which has been rendered so flexible by soaking in diluted muriatic acid that it can be tied into a knot.

If bones which have been treated in these ways be submitted to a careful chemical examination, it will be found that the bone which has been burned has lost all of its animal matter, the residue being a mixture of carbonates and phosphates of various bases. The bone which was immersed in acid will be found, on the other hand, to have lost all its mineral matter, the animal or vitalized organized portion of the bone remaining.

A careful analysis of the bones conducted in this manner, by the aid of the most refined processes known to chemical science, has determined the composition of bone to be as shown in the following table:—

Organic Matter,	Gelatine and blood-vessels,	33.30
Inorganic, or Earthy matter,	Phosphate of lime,	51.04
	Carbonate of lime,	11.30
	Fluoride of calcium,	2.00
	Phosphate of magnesia,	1.16
	Soda and chloride of sodium,	1.20
		100.00

In childhood the proportion of animal matter is much greater, so that the bones of infants and children are much more flexible than those of older people, and much less liable to fracture. In old age, on the contrary, the proportion of mineral matter greatly increases, so that the bones become exceedingly brittle, and break with very slight violence. A child will fall several feet without suffering graver injury than slight bruises which will heal in a few hours. An old person, suffering half the violence, will not escape without broken limbs. It has often happened that an elderly person has broken an arm or a leg by simply rolling off the bed during sleep, or even tripping upon a door-sill and falling upon the floor.

HYGIENE OF THE BONES.

Although the bones when once well formed are much less liable to disease than most of the softer parts of the body, yet they are undoubtedly affected by various morbid influences, and during the period of development are especially liable to become diseased in a variety of ways. We shall attempt to point out in as brief and concise a manner as possible some of the principal sources of danger to the integrity of this part of the system and the means necessary to secure the healthy development of the bones in early life, and their maintenance in a healthy condition in adult life.

Proper Development.—First of all, proper development is essential to the health of the bones as well as of other tissues of the body. If a morbid condition has been received by inheritance, of course the defect cannot be remedied; but most frequently faulty development is due to

faults which can be avoided. The chief causes of faulty development may be said to be,—

1. *Improper Food.*—By improper food we mean that which is lacking in the elements of nutrition necessary to form healthy bones. This is sometimes due to poor health, as defective digestion, on the part of the mother, so that the food she furnishes her infant both before and after birth is lacking in the proper elements of nutrition not only for the bones but for all the tissues. The defect may be in the quality of the mother's food. If she attempts to gain nourishment from fine-flour bread, strong tea, and lager beer, with perhaps a long list of harmful articles besides, the child will certainly suffer, not only with defective bones, but with defective mental development, and will be lacking generally.

Not infrequently, perhaps most often, defective nutrition for the bones arises from the attempt to rear an infant by hand upon such trash as corn-starch, tapioca, fine-flour gruel, and almost any one of a dozen varieties of "baby food" which are lauded in the newspapers, but the only recommendation of which is that they hasten the little sufferers out of misery. No food is so good for the young infant as that furnished it by nature. If through illness or incapacity the mother is unable to furnish the proper quality or amount of food, then cow's or goat's milk, or some other proper substitute, should be provided. Full directions for such cases are given under the proper heading.

Another cause of defective development is deficient or too early exercise. Children that are kept constantly confined indoors cannot develop strong, healthy bones, any more than they can develop vigorous muscles. Exercise is essential to the development of every organ of the body, as well as to the maintenance of health in organs originally well developed.

On the other hand, allowing children to begin to exercise too early, as attempting to teach them to walk before the bones have acquired sufficient firmness to sustain without injury the weight of the body, may dwarf and deform a child so that proper development may be impossible.

Putting children at work at employments which tax them by requiring continuous application for long periods is a most injurious and inhuman practice. When this is done, ossification is hastened, and becomes completed before the individual has attained his full growth, thus dwarfing him. The thousands of diminutive young men and women to be

found in the vicinity of large manufacturing cities bear testimony to the truth of this observation.

The bones of young children are soft and pliable, and yield when subjected to more strain than they can bear, thus becoming distorted. The exercise of children should always be varied, and should be given with frequent intervals for rest. Prolonged action is much more taxing to children than more violent exercise with frequent periods of rest; but both should be avoided. Moderate exertion and plenty of rest are the essential principles of development by exercise for children.

Spinal Curvatures.—Almost a volume might be written on the evil results of improper positions assumed in lying, sitting, standing, and walking; but our space is limited, and as the subject will be again referred to under the head of "Hygiene of the Muscles" we shall now simply touch upon the most important points which bear particularly upon the hygiene of the bones. It is in childhood especially that errors of this kind exert most strongly their baneful influence.

Probably to improper positions in school-rooms, where boys and girls as students are usually confined several hours of each of five days in the week, is due a large share of the distortions of the spine which are so exceedingly common nowadays. Dress-makers and most tailors are well posted on the frequency of spinal curvature, on account of the great number of instances in which dresses, coats, and other garments have to be cut and padded to hide deformities of this sort. Spinal curvatures are much more common among young ladies than in the opposite sex, for the reason that young men and boys usually engage in such vigorous, active sports out of school-hours that the evils occasioned by confinement in improper attitudes are in a considerable degree counteracted. We have for several years made a special point of observing with considerable care the persons whom we meet in traveling, in the streets, and in various other ways, with reference to this point; and we have been astonished to see in what a large proportion of young persons, particularly young ladies, some degree of variation of the spinal column from the natural form exists. We have noticed particularly on more than one occasion the very great frequency of this form of deformity in young ladies in attendance at our city schools. In cases in which the curvature is lateral it may be discovered at a glance by the difference in prominence of the two shoulders. The shoulder upon the concave or hollow side of the curve is always lower than that on the opposite side.

One great cause of the serious injury to students, and especially the younger class of school-children, is the use of improper seats and desks, or seats and desks not adapted to the age or size of those who occupy them. It may be well to remark, however, that the evil is becoming generally recognized by our foremost educators, and the improvements already made in this direction by manufacturers give reason to hope that the difficulty will soon be remedied, so far as the mechanical construction of seats and desks is concerned. But this alone will not remedy the evil; teachers must fully appreciate its gravity and must do their part in inducing students to assume and maintain a correct attitude in sitting at their studies. When engaged in study, students, especially if they are near-sighted or if the light is poor or print defective, are very apt to lean forward until the spine is very considerably curved. This is especially the case when engaged in ciphering or writing. The effect of this is to produce a permanent forward curving of the spine, and round shoulders, a deformity the most serious aspect of which is by no means its detraction from the good appearance of an individual. At the same time, most generally, a lateral curvature is produced by sitting with one arm upon the desk while the other is not, the desk being so high as to require the shoulder to be elevated to bring the elbow upon it. This position is a very common one with students, and to it is due the greater share of the cases of lateral curvature.

At first a curvature is only a functional distortion, being due to weakening of some of the muscles of the back, but by degrees it becomes permanent, as will be seen by a glance at the structure of the spinal column. It will be recollected that the vertebral column is made up of twenty-four separate bones arranged one above another, with discs of elastic cartilage between. It will also be recollected that the observation was made that these cartilages may lose their elasticity in some degree by continuous pressure, so that they become thinned, thus making a person shorter at night than in the morning, the variation being from one to two inches in different persons, and according to the amount of exercise taken. From these facts it will be readily seen that if the spinal column be bent and retained in a curved position for any considerable time, the discs of cartilage will become thinner upon the side upon which the pressure is applied, that is upon the hollow side of the curve, than upon the opposite side. Again, it will be readily understood that if this occurs daily for a con-

siderable period, the thinning upon the side brought under pressure may become permanent. This is exactly what does occur. The cartilages, which are naturally of equal thickness on the two sides, become so changed that they resemble wedges. This is well seen in the illustrations. See Figs. 34, 35.

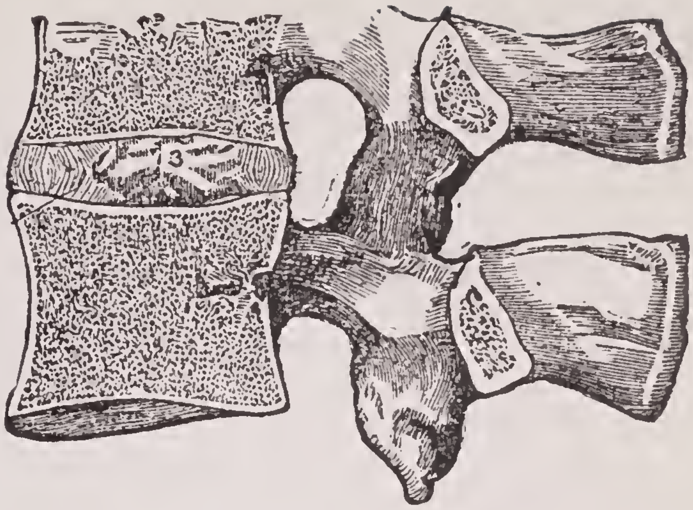


Fig. 34. Section of vertebræ, showing, at 3, Fibro-Cartilage Disc of normal shape.

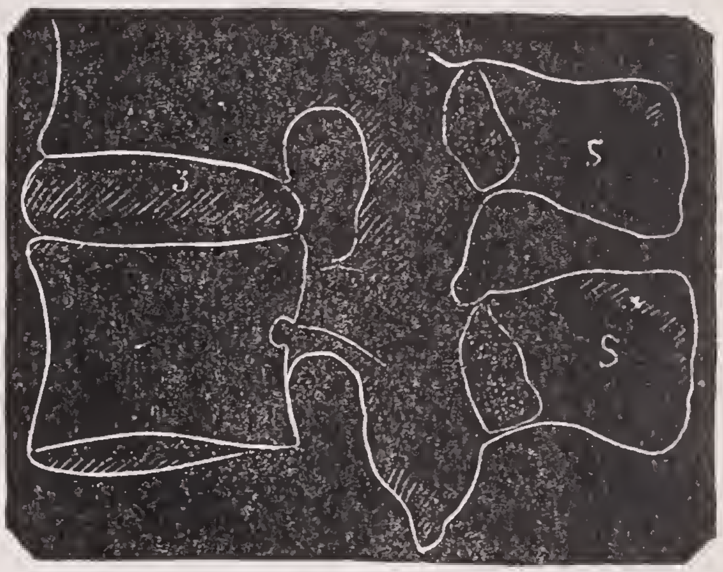


Fig. 35. Diagram showing the Cartilage, 3, thickened as the result of an anterior curvature of the spine, the spines of the vertebræ, *ss*, being brought near together.

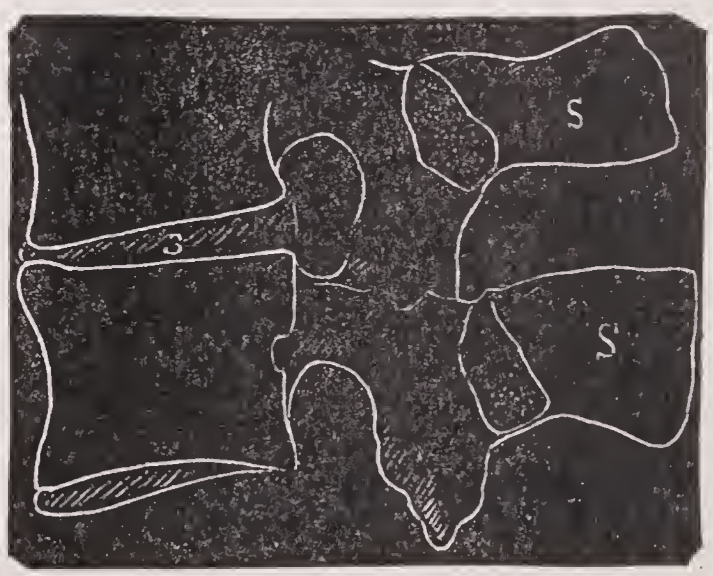


Fig. 36. Diagram showing the Cartilage, 3, thinned by pressure resulting from a posterior curvature, the ends of the spines, *ss*, being separated more than usual.

We have in our possession a section of the spinal column which we removed from the body of an individual in whom it had become so curved as to almost exactly resemble the letter S. In this case the cartilages were in exactly the condition represented in the accompanying cut above referred to. We have recently had under treatment a number of cases of this sort in young ladies, whose bad positions assumed in sitting at school were wholly responsible for the deformity of which they suffered. In one instance in which there was double curvature of spine, as represented in Fig. 37, the young lady's height was increased by treatment two inches in a few weeks, by simply straightening the spine and restoring the cartilage discs to their proper uniform thickness. In another case an inch and a half was gained in the same way, though in the latter instance there was posterior as

well as double lateral curvature. The mode of treatment employed is detailed elsewhere.

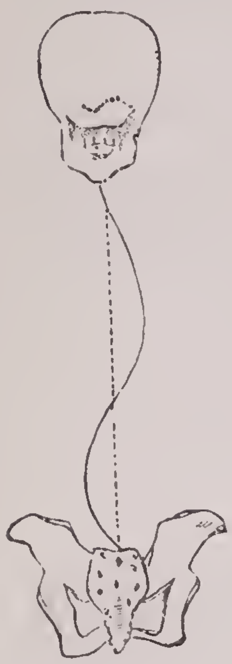


Fig. 37.
Double curvature of the spine.

It is too evident to need special explanation that if the permanent thinning of the intervertebral cartilages has existed a very long time no method of treatment will be of avail. Hence the importance, not only of taking every precaution to prevent the evil in the first place, but of adopting the necessary curative measure as soon as the deformity is discovered.

Deformity from Tight-Lacing.—While the bones suffer the least of any organs from the absurd custom which fashion has imposed upon the gentler sex,—and, we are informed, at times upon the other sex as well,—tight-lacing the waist and encasing the body in a vise of stays of bone or steel, is of positive and often incurable injury to this part of the vital economy, and is indirectly the source of far greater damage to more vital parts.

The reader will recall that in considering the anatomy of the thorax attention was called to the fact that the bony ribs do not join the sternum or breast-bone directly, but indirectly through the medium of flexible cartilages, an arrangement which gives to the thorax the power to expand and thus enable the lungs the better to perform their important functions. Careful study has shown that this flexibility of the costal cartilages is due to their constant exercise. Day and night, sleeping or waking, twenty times a minute, these flexible parts are bent and allowed to return again to their natural position. This constant bending and unbending allows them no opportunity to become stiff and unyielding like the bones. But when the chest is imprisoned in a corset, this constant movement becomes impossible ; and the consequence is that a process of stiffening is set up, and after a time the once flexible, yielding cartilages become as rigid as the rest of the ribs. The inevitable result of this change is a permanent limitation of the movements of the lungs. It becomes impossible for them to expand except to a limited degree upward and downward. Lateral expansion is as impossible when the corset is laid aside as when it is in place. The deformity, which was at first temporary, has become permanent. There are thousands of delicate ladies all over the land whose costal cartilages have been thus changed through their own willful abuse of their bodies, and who will undoubtedly go down into premature graves in consequence, in spite of all that the most skillful physicians can do for them.

The chest ought to be capable of expansion from two to five inches, —even greater expansion is attainable. But if you put a tape-line around one of these corset-stiffened chests you will be unable to obtain more than a scant quarter-inch of difference in measurement between the chest when empty and when filled to its utmost capacity. We have often tried the experiment when making physical examinations of the chest, and though the patient is almost always anxious to do her best, in order to demonstrate if possible what every lady will eagerly contend for, that her corset never did her any harm because it was worn so loose, and so draws up her shoulders to her utmost and makes a desperate attempt to swallow more air than there is room for, we have often found that the expansion of the sides of the chest was so slight as to be imperceptible. If tight-lacing did no other harm than this, we should certainly wish to condemn it in the strongest terms we could find language to express; and we cannot help feeling sometimes that it is a great misappropriation of money to support an army of missionaries among the inappreciative and degenerated inhabitants of African jungles and other heathen countries, who value human life so little that they feed their superfluous little ones to the crocodiles, and sacrifice a score of women to commemorate the death of a king, while there are so many thousands, perhaps millions, in civilized lands who are sacrificing lives which might be a hundred-fold more useful, in ways equally absurd and senseless. Let us have health missionaries to go into every city, village, and community, and preach the life-saving gospel of health. Such a mission is needed; and it ought to be instituted and supported, even if at the expense of some of our numerous and worthy, though far less important, missions to the degraded and benighted of foreign lands.

Abuse of the Feet.—Though we have not space here to elucidate fully the subject of the hygiene of the feet, we cannot forbear calling attention to the very common evil practices which relate to them. Nothing could be more absurd than the modern mode of dressing the feet. If some of the shoes and boots which we have seen worn, and which seemed to be highly prized by the wearers as being in the height of fashion, had been constructed by the Inquisition, and the same individuals had been compelled to wear them in punishment for some real or alleged crime, they would have been regarded as diabolical instruments of torture; and so they are. Who has not seen a young miss mincing along in a wholly unnatural way, vainly striving not to seem to limp,

in the sinful attempt to compel her feet to be reconciled to the scanty capacity of a pair of shoes two sizes too small for her. Within a short period, Fashion has let go her iron grasp upon the young men; but she still holds as firm a grip as ever upon the tender feet of misses and maidens as well as their elder sisters and mothers, and compels them to place upon their feet pretenses of coverings which cannot but produce discomfort and disease. The narrow soles, and high, narrow heels set forward near the middle of the foot, are qualities most worthy of being heartily despised; and the man or woman who invented the foot-covering possessing these properties, so finely adapted to torture the feminine foot, is responsible for an amount of discomfort and misery, individual and domestic unhappiness, and possibly of actual vice, which certainly entitles him to the dishonor of being heartily despised and abundantly reproached by the whole human kind.

A year or two ago we thought Fashion had concluded to be sensible at last, at least in the matter of foot-coverings, but alas for our hopes! Another turn of the wheel and she comes up as fickle and untrue to the requirements of Nature as ever, and demands that woman shall wear French heels, or be ostracized from the society of the *élite*, which to the majority of fashionable women would be a fate as bad or worse than death. We declare without mental reservation and without the slightest remorse of conscience, as a professional man and as a professed champion of truth, that a French slipper or shoe, as made at present (in the year 1880), is as unfit for a human foot as a horseshoe. Far more sensible would it be to return to the ancient custom and wear the rude, homely sandals which graced the feet of the maidens of ancient Egypt and the Orient.

But let us look a moment at the real evils of these fashionable coverings for the feet, at least for ladies' feet. The custom of wearing tight shoes with narrow soles and high, narrow heels, begins in early maidenhood, if not in childhood or infancy,—and sometimes the absurd fashion even seizes upon the child as soon as she leaves the cradle, for the precocious little one is so smart she must be a lady at once, and so must do as ladies do. At this period the bones are so soft and flexible, the ligaments so yielding, that they are easily forced into almost any mold, and the process of deforming them begins. The small boot or gaiter worn,—and it is always as small as can possibly be pressed upon the foot with the thinnest possible stocking,—allows no room for development of the organ, and the improper shape produces deformity and distortion. The fash-

ionable American girl does in a somewhat more limited degree exactly what is done for the Chinese maiden by a process of bandaging, of which we will elsewhere give our readers a description. The narrow soles and small toes cramp the foot and prevent it from supporting the weight of the body upon its whole under surface as designed by nature. The high heel throws the weight forward upon the toes, which still further embarrasses them in their cramped condition, and greatly increases the injury arising from narrow toes and soles. We have often witnessed some of these unfortunate young women tiptoeing along the streets, evidently conscious of appearing awkward and uncouth, and vainly endeavoring to conceal their crippling gait. The farther toward the toes the heel is set, the worse this difficulty becomes. In some of the latest foreign styles the wearer is barely able to touch her toe to the ground, except at the risk of tipping over forward, and when walking appears like a person stumping along on stilts. We heartily believe in laws against stealing, defrauding, taking life, disturbing the peace, even for the prohibition of the sale of liquor, and we can conceive of no reason why a shoemaker who deliberately goes to work and manufactures an instrument of torture which he perfectly well knows must spoil the happiness, ruin the temper, and make cripples of half the women of christendom, should not be placed under the ban of the law and visited with punishment commensurate to his crimes.

But perhaps we are beginning at the wrong end. It cannot be denied that ladies can obtain if they wish loosely fitting shoes, with broad soles, wide toes, and low and wide heels, and made of leather sufficiently thick to afford at least as much protection as a good quality of brown paper from the dampness and chilliness of the moist walks which must be encountered during the greater part of the year out of doors. If ladies will do their duty by themselves and their daughters, the evil may be speedily corrected; for French heels will not be made only so long as there is a demand for them. We are not sure, after all, but they owe their existence far more to female vanity than to any malignant designs on the part of the shoemakers.

THE MUSCLES.

The muscles constitute the flesh, or lean meat, of animals. Their general structure may be readily seen in the boiled leg of a fowl. By a little care the round mass of flesh forming the thigh may be separated into coarse fibres, which by careful manipulation can be still further divided into tiny threads. Under the microscope the finest fibres which can be seen by the naked eye are found to be composed of still smaller fibres, which are the anatomical elements of muscular tissue, and have already been studied. In a muscle these minute fibres are bound up in little bundles, which are again united into larger bundles, and these are bound up together in a common sheath to form the complete muscle.

Two Kinds of Muscles.—As already pointed out, there are two varieties of muscles, which are distinguished both by their structure and by their mode of action. They are known as *voluntary* and *involuntary* muscles. The voluntary muscles are chiefly located upon the exterior of the body, giving roundness and symmetry to the form. They are employed in all voluntary motions. The involuntary muscles are chiefly found in the interior of the body, in membranes, the walls of cavities, of blood-vessels, and of the various outlets of the body. Involuntary fibres also abound in the skin, being attached near the roots of the hairs. It is by their contraction that the skin is made to assume the appearance of goose-flesh.

The Tendons.—In order to give the muscles strength and greater efficiency they are not usually attached directly to the bones with which they are connected, and in conjunction with which they give rise to the various movements of which the body is capable, but are united to them by means of tendons, which are white, glistening bodies composed of tough, inelastic, fibrous tissue similar to that which forms ligaments. Tendons are sometimes very short, but at other times are drawn out into long, thin cords, traveling some distance from the muscle before being attached to the bone.

Form and Arrangement of Muscles.—The voluntary muscles are of various forms, as will be seen by reference to the accompanying cuts, Figs. 37, 38, 39, and 40. By this diversity of form they are adapted to all the different positions in which they are required to act.


Fig. 37.


Fig. 38.

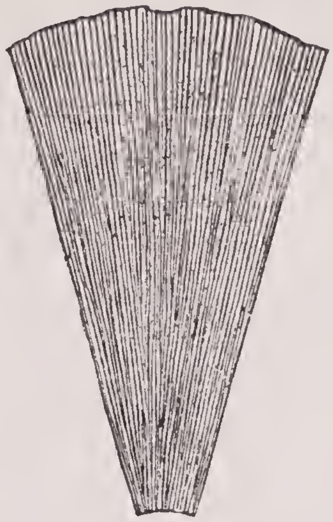


Fig. 39.


Fig. 40.

FIG. 37. Fusiform, or Spindle-Shaped Muscle, having a tendon at each end.
FIG. 38. Pennate, or Feather-Shaped Muscle.
FIG. 39. Fan-Shaped Muscle.
FIG. 40. Circular, or Orbicular Muscle.

The voluntary muscles, with few exceptions, exist in pairs, the two halves of the body being symmetrical.

NAMES AND ACTION OF SPECIAL MUSCLES.

Of the more than five hundred distinct muscles in the body we can mention but a very few of the most important. Indeed, the action of a large number of the smaller muscles is so obscured by others that it is hardly worth our while to attempt to study them closely. For the sake of convenience and brevity we will notice the action of each of the muscles named in immediate connection with its description, although this part more properly belongs to the physiology of the muscular system. See PLATE II, and Fig. 41, for a general view of the muscles.

Muscles of the Head.—See Figs. 42 and 43. The muscles of the head, including those of the face, are among the most interesting of all in the body. Of the large number of special muscles in this region only a few can be here mentioned by name.

The Occipito-Frontalis.—This muscle is attached to the skull at the back part of the head, and by means of a long, thin, flat tendon is carried over the top of the head to the forehead, the other end being attached to the skin of the latter region. The scalp is closely adherent to the tendon of the muscle. By contraction of this muscle the forehead is wrinkled and the eyebrows elevated. In some persons the muscle is under such complete control that the whole scalp can be moved very freely.

The Corrugator Supercilii.—This might be called the frowning muscle. It is located near the inner and upper border of the eye. By its contraction the skin of the forehead is drawn down and wrinkled, as in scowling.

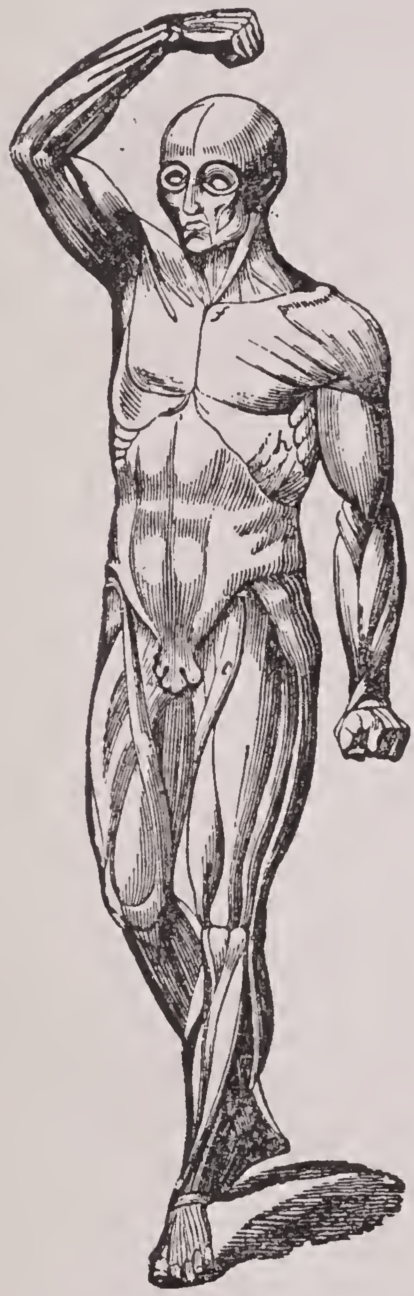


Fig. 41. General View of the Muscles.

Orbicularis Palpebrarum.—The little muscle which bears this long name is the circular muscle of the eye. Its fibres surround and aid in forming the eyelids, and by their contraction the eye is closed. There are several other muscles connected with the external parts of the eye, which we have not space to mention.

Auricular Muscles.—There are three little muscles connected with each ear, located just beneath the skin, which seem to be designed to move the external ear in various directions; but practically they are of no use in man. In lower animals these tiny muscles are developed into large and useful ones, as in the horse, dog, and rabbit. There may occasionally be found a person in whom these muscles are so well developed that the ear may be moved at will, though so slightly that no advantage can be derived from the action. Darwinian philosophers tell us that these rudimentary muscles are vestiges of the large, strong muscles possessed by man's primeval ancestors, who may have been able to use their ears as fly-brushes for the protection of the face.

Muscles of the Nose.—The soft parts of the nose are made up of muscles which compress its lower portion, elevate and depress and dilate the nostrils, each receiving a name descriptive of its particular function. One of the little muscles which operate upon the nose carries the most formidable name of any muscle in the body, being designated as the *levator labii superioris alæque nasi,* which translated means the elevator of the upper lip and of the nostril.

Muscles of the Mouth.—Nine pairs of muscles operate upon the mouth and lips, their stationary ends being attached to the bones of the

face adjacent to the mouth, and their moving ends being connected by a circular muscle which surrounds the mouth, known as the *orbicularis oris.* The use of the last-named muscle is to aid in closing the mouth and to pucker the lips as in whistling.

Muscles of Expression.—Most of the muscles connected with the mouth and lips are chiefly useful in giving expression to the countenance. Through the action of these muscles, together with those of the external parts of the eye and nose, the face becomes a mirror of the mind. For instance, when feelings of joy or merriment are experienced the muscles of the upper part of the face contract in such a way as to drag the corners of the mouth outward and slightly upward, as in laughing or smiling. When opposite emotions are experienced, as in grief or sullenness, the corners of the mouth are drawn down, the muscles of the lower part of the face being contracted in such a way as to draw the lines of expression downward. All other emotions of the mind are indicated with equal distinctness, so that a person of any degree of experience in observing men and things can tell with almost absolute certainty the general tenor of the thoughts of one to whom he is speaking. So close is the relation between the mind and the muscles of expression that it is absolutely impossible for a person to be strongly affected by any emotion without in some degree exhibiting the same in the face. For example, it is not possible for a person to be merry in mind and at the same time assume an appearance of grief upon the face which could not readily be detected as an attempt at deception.

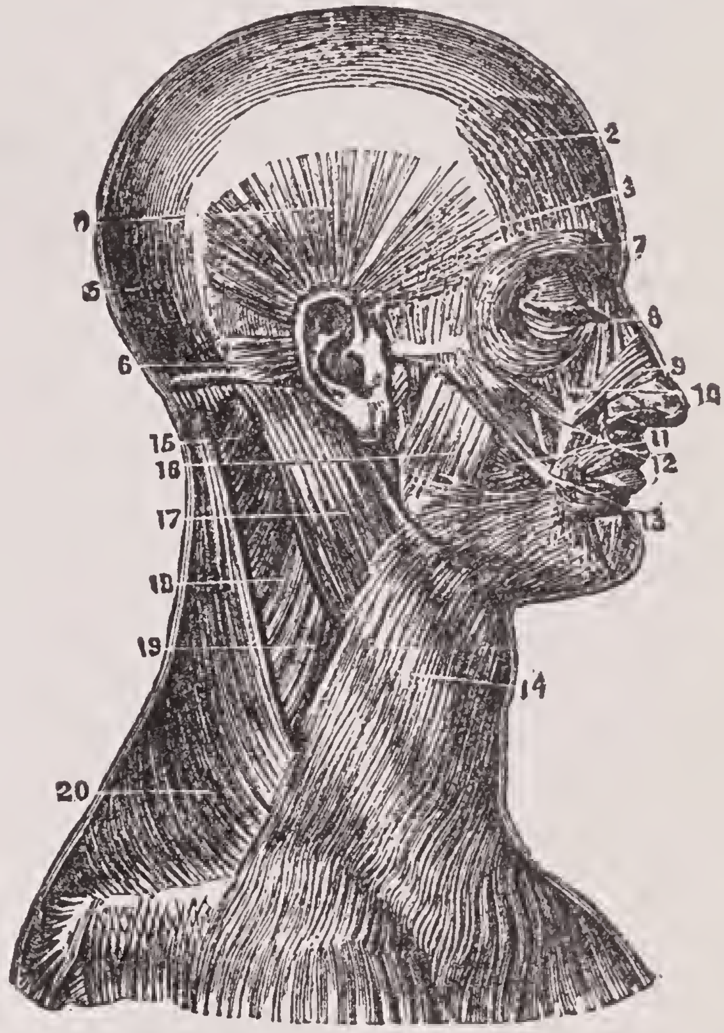


Fig. 42. 2 and 5. Occipito-frontalis; 3, 4, and 6. Muscles of the Ear; 7. Orbicularis Palpebrarum; 8. Levator Labii Superioris Alæque Nasi; 9. Compressor Naris; 10. Levator Anguli Oris; 11. Buccinator; 12. Zygomaticus Minor; 13. Orbicularis Oris and Zygomaticus Major; 14. Platysma Myoides; 15. Splenius; 16. Masseter; 17. Sterno-cleido-mastoid; 18. Levator Scapulæ; 19. Scalenus Medius; 20. Trapezius.

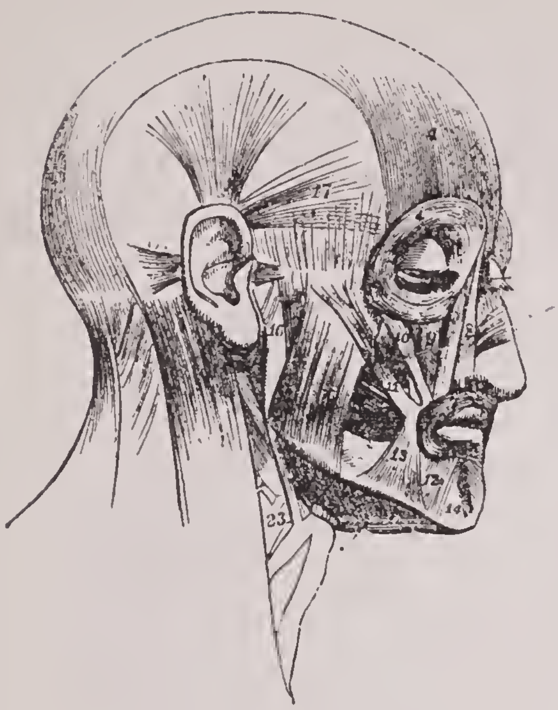


Fig. 43. This cut shows with greater distinctness some of the deeper Muscles of the Face, and those of its lower part.

Muscles of Mastication.—Besides the muscles of the face already mentioned, there is a set of muscles located at the back part of the cheek which are attached at one end to the skull and upper bones of the face, and at the other to the inferior jaw-bone. These are quite strong muscles, and their function is to move the lower jaw in talking, and particularly in mastication. The principal muscles for this purpose are the *temporal* and the *masseter*.

Internal Muscles of the Eye.—The system of muscles by which the eye is moved is one of the most marvelous exhibitions of mechanism in the body. The motions of the eyeball are produced by six slender muscles which chiefly arise from the bottom of the socket behind the eye, and are attached to its outer covering. Four of these produce the movements of the eye upward, downward, to the right, and to the left. The other two are ingeniously arranged in such a manner as to roll the eye and to move it in an oblique direction, hence they are known as the oblique muscles of the eye. One of these, the superior oblique, operates by means of a pulley arrangement, its tendon passing through a loop and changing its direction before being inserted into the eyeball. By the combined action of these several muscles, all the different motions are obtained. All acting in rapid succession cause the eye to roll in its socket in such a way as to enable the sight to describe a complete circle. In persons who are cross-eyed or wall-eyed, some of the muscles just described are affected. For illustration of muscles of the eye, see Fig. 44.

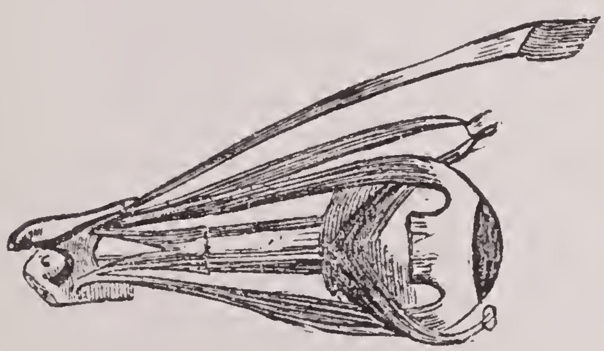


Fig. 44. Showing the Muscles of the Eye.

Internal Ear Muscles.—Within the interior of the ear there are to be found three little muscles, the most delicate in the whole body, which operate upon the minute ear bones and other parts of the middle ear in regulating the function of hearing.

Muscles of the Neck.—The muscles of the neck may be rudely divided into two sets; those in front, and those of the back part of the neck. The anterior muscles are useful in depressing the lower jaw, in raising the bone of the throat, in compressing the throat and controlling the organs used in speaking and swallowing, and to bend the head forward.

The muscles of the back part of the neck are chiefly useful for moving the head. By their action the head may be thrown backward or to one side. They are quite strong muscles, and are needed to enable a person to maintain the head in an erect position. A long, slim muscle which passes from the back part of the head to the upper end of the breast-bone, called the *sterno-cleido-mastoid* muscle, by contraction becomes the cause of wry neck, for which disease it is sometimes necessary to divide it by a surgical operation.

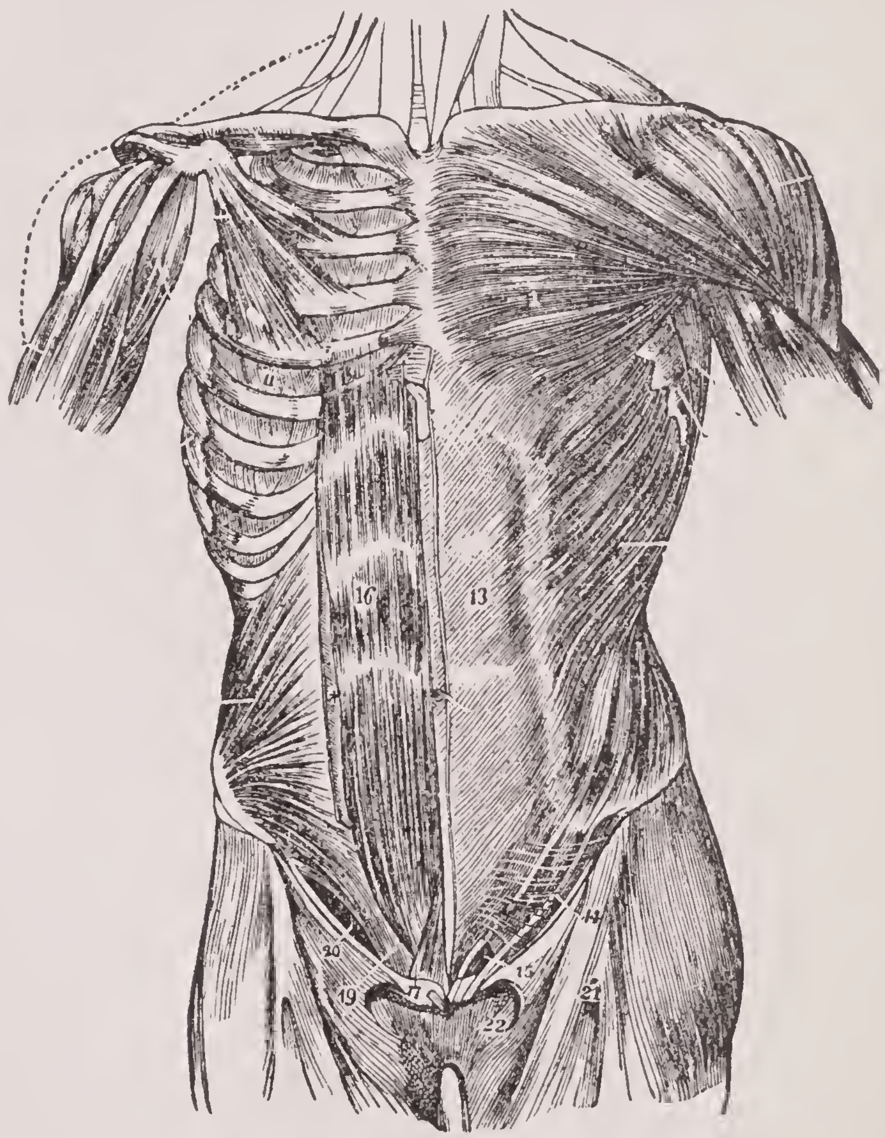


Fig. 45. Showing Muscles of the Trunk

Muscles of the Trunk.—These also may be divided into two groups, those found upon the front of the trunk, and those upon the back. The muscles of the front form the principal portion of the abdominal walls. They are attached to the borders of the ribs and the breast-bone above, and to the edges of the pelvis below. They bend the body forward, and assist in keeping it erect. They are also exceedingly useful in respiration, and aid in several other vital operations. Between each two ribs there is a double set of muscles which assist in the contraction and expansion of the thorax in respiration. The upper part of the chest also affords attachment to several large muscles which act upon the upper extremities. The muscles of the back are exceedingly numerous,

being arranged in five distinct layers. They arise for the most part from the projecting points of bone which have been already described as being found in great numbers on the vertebræ which make up the spinal column. Some also arise from the skull, from the ribs, and from the pelvis. They hold the body erect, give to the trunk a great variety of movements, draw the head backward, assist in moving the arm, and aid in respiration. This is undoubtedly the most complicated part of the muscular system. For a view of the muscles of the trunk, see Fig. 45.

Muscles within the Trunk.—Of the muscles within the trunk of the body the most important is the *diaphragm*, which is a broad, circular muscle dividing the cavity of the thorax from that of the abdomen. Its outer border is attached throughout its whole circumference to the lower parts of the ribs and their cartilages and the upper lumbar vertebræ. The muscular fibres converge from the circumference and unite in the center in a large, flat, tendonous portion which forms the center of the diaphragm. In a state of rest, the muscle rises into the cavity of the thorax like a dome. By its contraction it becomes depressed to a more nearly horizontal position, thus aiding inspiration by increasing the size of the thoracic cavity. The diaphragm is one of the most important muscles of the body. Though voluntary in its structure and under control of the will, like the other ordinary muscles of respiration it acts involuntarily, and thus carries on the process of respiration during sleep.

The other muscles found within the trunk are connected with the lower extremities, arising upon the inner sides of the pelvis and passing out to be attached to the upper part of the thigh bones. They are useful for turning the limb so as to bring the toes outward, to aid in holding the body erect and in bending it.

Muscles of the Upper Extremities.—These comprise the muscles of the shoulder, arm, fore-arm, and hand. Most of the muscles of the shoulder assist the movements of the arm, and so do not require special notice. The arm proper is acted upon by eleven muscles, eight of which are attached to the scapula. The remaining three arise from the trunk of the body and the fore-arm. The most important of these are the *deltoid*, which covers the shoulder and raises the arm to a horizontal position; the *pectoralis major*, which brings the arm forward upon the chest—this is the muscle chiefly used by birds in flying, being in them enormously developed; the *lattissimus dorsi*, a large muscle which arises from the trunk and is connected with the upper and back part of the arm, which it draws backward and to the side.

The movements of the fore-arm are freer than those of any other part of the body unless it be the hand. Its principal motions are *flexion*, bending upon the arm; *extension*, restoration to its straight condition after flexion; *rotation inward*, turning of the palm of the hand toward the body; *rotation outward*, movement in the opposite direction. These movements are accomplished by thirteen different muscles, most of which arise from the scapula and arm, and are attached to different parts of the bones of the fore-arm. The most important of these are, the *biceps*, which is the principal muscle employed in flexion of the fore-arm; the *triceps*, which extends the fore-arm, antagonizing the biceps; the *pronator teres* and *pronator quadratus*, which turn the arm inward; and the *supinator brevis*, which rotates it outward.

Muscles of the Wrist.—The wrist is moved by sixteen different muscles, its chief movements being forward, backward, outward, and inward, movements in other directions being made by combinations of muscles operating in these different ways. The principal muscles of the wrist proper are, one which flexes it upon the ulna, another which flexes it upon the radius, and two muscles, a long one and a short one, which extend the wrist, antagonizing the flexors.

Muscles of the Thumb and Fingers.—The thumb and fingers of each hand are operated by eighteen different muscles, half of which are capable of producing several different motions. It is this fact which gives to the human hand the wonderful dexterity which enables man to carry into execution the most subtle mechanical contrivances suggested by his active brain. It is claimed by some, and has not been contradicted that we are aware of, that the human hand has done almost as much to bring man to his present highly educated and civilized state as the brain itself, granting, of course, that the brain is the motive power. In no other known animal is there so great an independence of action in the digits as in man. The power of opposing the thumb to the four other digits is what gives the hand its greatest efficiency, enabling it to grasp very small objects between the ends of the fingers and the thumbs. The study of digits in different animals is an exceedingly interesting branch of knowledge.

Muscles of the Lower Extremities.—The muscles of the inferior extremities are in a great degree analogous to those of the arms, corresponding quite closely in number, relation, and function.

Muscles of the Thigh.—These are chiefly large, strong muscles, aris-

ing from the pelvis. The thigh is moved by twenty distinct muscles, the principal of which are the three *glutei* muscles which form the fleshy part of the hip, and the three *adductor* muscles which draw the limb forcibly toward the central line of the body.

The Muscles of the Leg.—The leg is moved by ten muscles, the chief of which are, the *biceps*, by which it is flexed upon the thigh; the *rectus femoris*, by which the leg is extended or straightened—it is the lower end of this muscle which is inserted into the knee-cap or patella, which is in turn attached by a ligament to the upper part of the leg bone, or tibia; and the *sartorius*, or tailor's muscle, which is used in crossing the legs beneath the body when sitting down in tailor fashion.

Muscles of the Foot.—The ankle and toes are moved by twenty separate muscles, of which we will only mention the *gastrocnemius* and *soleus* which form the chief part of the calf of the leg. There is much less freedom of motion in the digits of the feet than in those of the hand, although the number and relations of their muscles are much the same. A considerable degree of control over the toes can be obtained, however, by practice, as is shown in the case of persons who, being deprived of hands, have learned to write legibly with their toes.

PHYSIOLOGY OF THE MUSCLES.

The sole property of a muscular fibre is contractility. Muscular fibres are said to possess a natural irritability by means of which they respond to proper kinds of stimulation by contracting. The ordinary and most natural stimulus to muscular contraction is nerve force. Through the connection of the nerves with the muscles, nerve force generated in the living batteries of the system—the nerve cells of the brain and spinal cord—is communicated to the muscle fibres, which are by this means made to contract. Muscular fibres may also be made to contract by the stimulus of electricity, which in many respects very closely resembles the nerve force. Mechanical and chemical irritation, such as striking, tearing, or pinching the muscle, or applying an acid or some other irritant, has a similar effect.

It was formerly supposed that muscles could be made to contract only through the medium of nerves. It is now known, however, that this view is incorrect, since by direct irritation muscular contraction can be produced when the nerves are completely paralyzed.

The contractile power of muscular fibres is not only always present while they retain their life, but is always active. Contrary to the general supposition, the muscles are never quiet. They are always actively at work, and it is by means of this constant contraction that the symmetry of the body is preserved. A proof of this is found in the fact that when a single set of muscles is paralyzed, the part becomes distorted by the contraction of the antagonizing muscles. This is often seen in the face in cases of paralysis of one side. A short time ago we had under treatment a patient in whom the extensor muscles of both fore-arms had been paralyzed, so that there was loss of power to straighten the hands. The fingers were all bent toward the palm. The patient could lift quite a heavy weight, but could not open the hand, and could scarcely move a finger except to close it tighter. By the application of proper treatment to the paralyzed muscles upon the outer side of the arm the patient recovered the power to control the hand and straighten the fingers. This peculiar property is called muscular tonicity.

How a Muscle Contracts.—The contraction of a muscle, though very simple, is still interesting. If the arm be clasped with the hand, and the fore-arm be then bent, the hand being closed and a considerable degree of force exerted, as in lifting a heavy weight, it will be observed that the arm becomes larger, seeming to swell out beneath the grasp. If a single muscular fibre were under examination beneath a good microscope, as a live fibre just taken from a frog or a turtle, we might cause it to contract by a very feeble current of electricity; and should we do so, we should notice essentially the same thing; we should find that the fibre would become thicker, but at the same time it would become shorter. As already explained, a muscle is made up of a large number of fibres; and its contraction as a whole is due to the contraction of each one of the minute fibres which compose it. As each one of these thickens and shortens in the process, the whole muscle thickens and shortens. There is no increase in size in the muscle, but simply a change of form. This is the simple manner in which all motion is produced.

Mechanical Action of Muscles.—As elsewhere remarked, the muscles use the bones as levers in executing their various movements. Not only the lever but also the pulley, another mechanical power, is illustrated in the action of the muscles. It will be both interesting and profitable to notice some of these exhibitions of vital mechanics.

A lever consists essentially of a rigid bar of some sort, a point of rest for the bar, which may be at one end or at any point between the ends called the *fulcrum*, the *power*, which is applied to some part of the lever away from the fulcrum, and the *weight*, the object to be lifted. There are described three kinds of levers, which are illustrated in Figs. 46, 47, 48. In the first kind, it will be noticed that the weight is upon one side of the rest, or fulcrum, and the power on the other side. In the second kind of lever, shown in Fig. 47, the weight is between the power and the fulcrum. In both instances there is a gain of power, because the force is applied at the long arm of the lever. In the third class, Fig. 48, the power is between the weight and the fulcrum. Now the power is applied at a disadvantage, as the weight is at the long arm of the lever. However, there is compensation; for what is lost in power is gained in speed or motion.

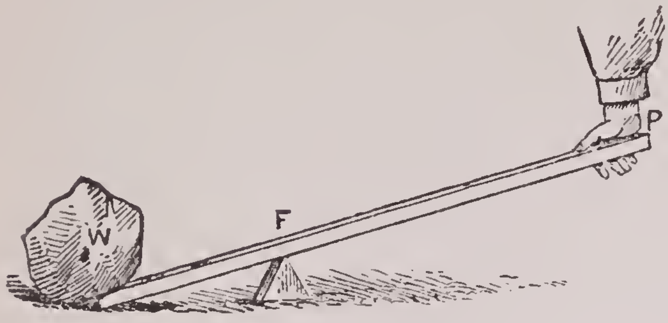


Fig. 46.

Now, regarding the muscles as the power, the bones as the levers, the work to be done, that is, the objects to be lifted, carried, pushed, or otherwise moved by the muscles, as the weight, let us see how these different forms of levers are illustrated in the human body.

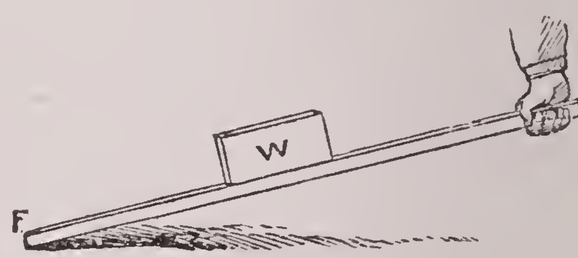


Fig. 47.

The first kind of lever is rarely illustrated in the body. It is found, however, as in the action of the muscles of the back of the neck upon the head. The top of the spinal column is the fulcrum, the head itself the lever, the muscles of the neck the power, and the front part of the head the weight to be lifted.

Illustrations of the other two kinds of levers are very abundant. In the foot, employed in the ordinary act of walking, we have a good illustration of a lever of the second class. When the body is supported on tiptoe, the foot is the lever, the earth the fulcrum, the body the weight, and the muscles of the calf the power. See Fig. 49.

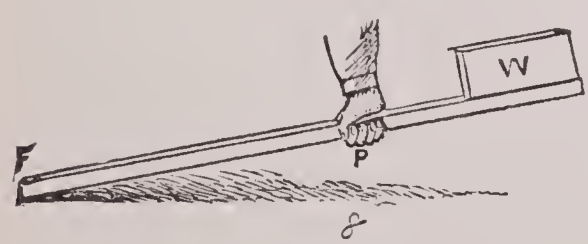


Fig 48.

Fig. 50 illustrates by the arm a lever of the third class. Here the fore-arm is the lever, the elbow is the fulcrum, the muscles of the fore-arm the power, and the dumb-bell lifted in the hand the weight. The power, being applied between the fulcrum and the weights, lifts the ball at a disadvantage, as it evidently requires more strength to hold the ball in position as shown in the figure than it would to lift it straight up with the arm by the side.

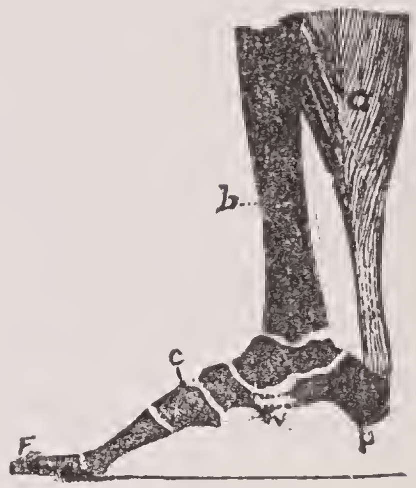


Fig. 49. In the above cut the foot, c, represents a lever with the fulcrum at F, the weight of the body lifted through the bones of the leg, joining the foot at W, and the power applied at P, the heel, through the contraction of the muscles of the calf, a.

It is not a mistake of nature that the muscles and bones of the arm are so arranged that the power is applied at a mechanical disadvantage, since what is lost in lifting power is gained in rapidity and extent of motion. By means of this arrangement the dexterity of the hands is very greatly increased, and they are far better fitted for the great variety of rapid movements which they are required to execute than they could otherwise be.

The pulley principle is beautifully and perfectly illustrated in one of the muscles of the eye, as before mentioned, and also in a muscle of the neck called the *di-gastric*, from the fact that it has two bellies, or fleshy portions. As will be seen in the cut (Fig. 51), the middle and tendonous portion of the muscle is held by a loop through which it plays, the loop constituting a real pulley. Marvelous indeed are the works of the Creator, and "fearfully and wonderfully made" is his creature, man.

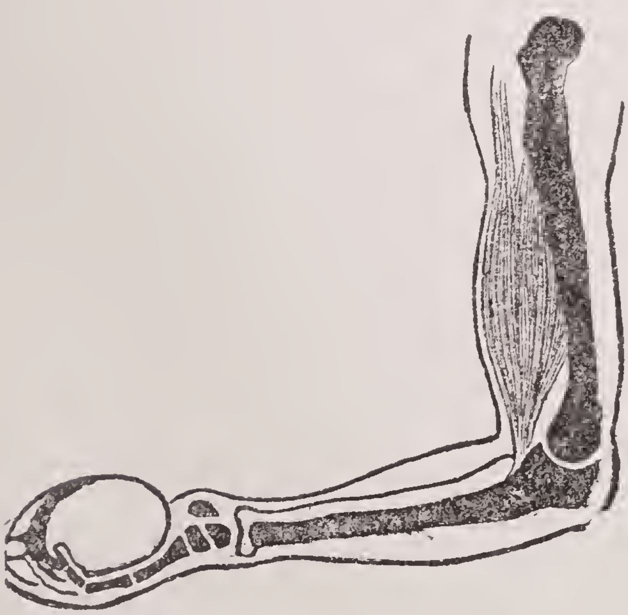


Fig. 50. The arm, representing a lever of the third class.

Uses of Muscles.—Incidentally the muscles add symmetry to the body. They fill up the hollows and cover up the rough excrescences of the bones, and in numerous ways add to the beauty and roundness of the form. But the really important function of the muscles is to produce motion. In this work the muscles are constantly engaged. Whether we sleep or wake, still the delicate muscular fibres

of the body are employed in unceasing activity, performing their part in the various vital processes necessary to life. Locomotion, manual motion, and vocalization, or speaking, are among the most important voluntary movements produced by muscular action; while respiration, digestion, and the circulation of the blood are equally or even more important processes, largely dependent upon both voluntary and involuntary muscular action.

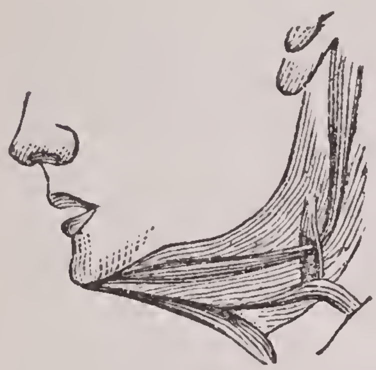


Fig. 51.

It may be well for us to devote a brief space to the consideration of how these several processes are performed.

Locomotion.—The act of walking, or progression from one point to another by means of muscular action, has been much studied by physiologists in both man and lower animals. Perhaps the simplest explanation of the act of walking would be that it is a continuous falling forward, the body being constantly saved from actually falling to the ground by the alternate placing forward of the feet to recover the equilibrium. The description of the several acts of walking, running, and leaping, are so admirably given by Prof. Dalton, one of the most lucid writers of the day on physiology, that we shall take the liberty to quote the following paragraphs from his pen:—

"The movements of walking, running, leaping, etc., are performed as follows: When the body stands upright, the feet are planted flat upon the ground, bearing at once upon the heels behind and the ball of the toes in front, the weight of the body resting between the two, upon the middle of the arch of the foot. The body is maintained in this position, as we have seen, by the various muscles, which act in such a way as to keep its different parts carefully balanced, and to retain the weight of the whole suspended exactly over the ankle-joint.

"Now in walking, when a movement is to be executed in advance, the body is first made to lean a little forward, so that its weight no longer remains above the ankle, but is thrown forward so as to rest entirely upon the toes. The heel is then lifted from the ground by the action of the very strong muscles situated on the back part of the leg, called the gastrocnemius and soleus muscles."

"At the moment that the body is raised and tilted forward in this way, the other foot is lifted entirely from the ground and swung forward so as to take a step in advance. As soon as the body has been

carried far enough in an onward direction, the second foot is also raised in the same manner as before, while the first is swung forward in its turn to take another step. In this way the two legs act alternately, the weight of the body being carried forward first by one and then by the other; all the muscles, however, upon the two sides combining harmoniously in their action, so as to produce an easy, graceful, and continuous movement.

"In the act of walking, as above described, one foot is always upon the ground, and the weight of the body is mainly supported in this way by bearing upon the toes; it is only lifted forward alternately on the two sides by the leverage of the bones of the foot. Consequently no violent muscular exertion is required, and the movement can be kept up for a long time without fatigue.

"The act of running, however, instead of being a series of steps, is performed by a succession of leaps or springs, in each of which the whole body is thrown clear of the ground, and carried forward by the impetus which it has received. In order to accomplish this, at the moment the heel is about to be raised by the action of the muscles above described, the knee and hip joints are first bent and then instantly straightened by the sudden contraction of their exterior muscles. The whole limb thus acts like a powerful spring, which, by its sudden extension, throws the entire body off the ground and carries it through the air in an onward direction. The opposite limb is at the same time thrown forward to receive the weight of the body and to perform, in its turn, and with similar rapidity, the same movements. The speed of the runner depends on the vigor of the muscular contractions, and the swiftness with which the successive motions are performed.

"The act of jumping is accomplished in a similar way to that of running, except that the same motions are executed by both limbs together, so that each leap is performed by itself, and is not combined with others in a continuous movement."

Manual Motion.—The great diversity of the movements of the hand admit of no general description. When we consider the large number of muscles which must be made to co-operate harmoniously in the production of a single movement of the hand, we are led to marvel at the wonderful degree of delicacy of touch and motion that is possible to a hand carefully trained to fine work. Jewelers, watchmakers, microscopists, and engravers exhibit this nicety of control of

the muscles of the arm and hand in a remarkable degree. The difference between a trained and an untrained hand is readily seen in comparing the manual motions of a skilled artisan with those of a backwoodsman, whose finest tool has been an ax or possibly a chisel.

In the dextrous use of the hand and arm, man is far superior to all lower orders. He may not be able to construct a bird's nest exactly like the one found in the forest tree, but he can make that which is vastly more delicate and more beautiful. If we except the human brain, with its marvelous properties of thinking, feeling, and willing, there is no more wonderful exhibition of creative skill than in the structure and functions of the human hand.

Speaking.—While voice is not wholly the result of muscular action, special organs being required to act in conjunction with the forcible expulsion of air by the expiratory muscles, it is really one result of motion, since without muscular effort the most elaborate vocal apparatus in the world could accomplish nothing. The great share of created animals possess some form of speech, as well as man, and it is in all produced chiefly by muscular action. This is as true of the birds which whistle and carol in the trees, as of the tiny insects which chirp and hum amid the shrubs and flowers.

Muscular Action in Respiration.—As already stated, respiration is performed by muscles which are really voluntary in character, being under the control of the will, but which are so controlled by the nervous system that they are kept in constant motion. The wisdom of this arrangement will be readily seen. Involuntary muscles are very slow in their action, while voluntary muscles act promptly and with vigor. Respiration is a function which requires continuous, and often rapid, execution. In emergencies it is often necessary that air should be inhaled or expelled with great promptness, which can only be done by voluntary muscles. Again, it is sometimes essential that the function of breathing should be suspended temporarily, as when the body is immersed in water or surrounded with smoke or noxious fumes, which could not well be done if it were performed by involuntary muscles.

Muscular Action in Digestion.—Prehension, the act of taking food, mastication, and the preliminary act of swallowing, are all performed by voluntary muscles; while the movement of the food along the alimentary canal, bringing it in contact with the various digestive juices and the absorbents by which it is digested and taken up into the blood,

is wholly due to involuntary muscles which form a large part of the walls of the œsophagus and the whole alimentary canal. The churning action of the stomach by which the gastric juice is as it were squeezed out and mingled with the food to be digested, is also due to muscular contraction.

Muscular Action in the Circulation of the Blood.—The circulation of the blood, through the means of the heart and blood-vessels, is almost entirely due to muscular effort. The heart is itself nothing more nor less than a hollow muscle, and the arteries are simply muscular tubes. The contractile action of the heart is continued through the arteries, and thus the blood is forced out into the veins, through which it is urged along, both by the pressure from behind and by the squeezing action of the muscles as they bulge in contraction.

Relation of Muscles and Nerves.—During life the muscular system is wholly controlled by the nervous system. Every contraction, whether of a voluntary or of an involuntary muscle, is instigated by an impulse sent out from the nervous system. Hence it will be readily seen that the muscles are wholly under the domain of the nerves, and must depend for their utility and efficiency upon the integrity of the source of their force and activity. The muscles may be in reality strong, being well nourished ; but if the nervous system is weak and exhausted, the muscles cannot manifest the force of which they are really capable.

Fatigue.—Muscular action occasions muscular wear and waste. The most delicate contraction of the smallest muscle is accompanied by a definite amount of destruction of tissue. The greater the amount or intensity of muscular effort, the greater the amount of waste. Only a certain degree of destruction of tissue by action is possible. After the muscular tissues have wasted to a certain degree, they refuse to respond to the demands of the nerves. A violent effort of the will may secure a slight additional amount of work, but even the most powerful exercise of will cannot excite to action a muscular system which has been exhausted by prolonged activity. The sense of weariness, inability or incapacity for action which follows violent or prolonged exertion, is called fatigue. Its cause we have already seen. The sense of fatigue is a demand of nature for rest, for time to repair the wasted tissues, an admonition that the system must have rest. This provision nature has wisely made to oblige us to stop the vital machinery before it has become so much damaged that repairs cannot be made. This admonition comes

with such force that it cannot be resisted for any length of time. Unfortunately for the race, however, ingenious man has discovered that there are agents which will quiet or smother this warning voice, thus allowing the individual to go on destroying his tissues beyond the point of safety at which nature admonishes him to stop. Alcohol and tobacco are among the most active and frequently used of these substances, and tea and coffee belong in the same category. Very strangely, too, these agents are employed and recommended for the very purpose which renders them dangerous, and that, too, by men of learning and intelligence on most subjects, but who fail to see the folly of their action in this particular case. Alcohol, tobacco, tea, coffee, opium, hashish, and other narcotics and stimulants, will make a man feel well, and think he is not tired when he is exhausted; but they will not give him additional strength. By deceiving him they will enable him to get a little more work out of his muscles, to waste them a little more, but they do not supply him any force to use in the extra labor. A tired man is no more saved from the effects of overlabor, except in his feelings, by a glass of grog, a pipe or chew of tobacco, or a cigar, or a cup of tea or coffee, than a patient is saved from the results of the surgeon's knife by being made insensible by an anesthetic. The action is precisely the same in both cases. The individual feels better, but only because his sensibilities are benumbed, because he is deceived, not because he is really better. The fact is that he is worse off. Statistics show that patients are less likely to make good recoveries from the effects of surgical operations when chloroform is used than when it is not used. Just so it is with the substances named; when taken to relieve fatigue or to enable a person to do more work, they really damage the individual more or less permanently, because they make it impossible for him to recruit so well when the period of rest is obtained. The proper course to pursue is to stop work when nature says "enough," and rest. Stimulants only put off the day of reckoning for a little time, and they run up an enormous account to be answered for when the day of retribution comes.

Muscular Electricity.—Experiments upon both human beings and animals have clearly demonstrated that the human body is a real electrical battery, generating appreciable quantities of electricity by every vital act. Every muscular contraction generates a current of electricity the exact quantity and quality of which can be determined by the proper instruments. There is no special electrical apparatus in the human body, as in certain fishes and other curious animals which pro-

duce this subtile agent in prodigious quantities, but the whole body develops it. Every breath we draw, every heart-beat, every wink of the eye, even every thought, generates the same element that darts destruction from the thunder cloud, and flashes intelligence around the world. This interesting fact has an important bearing on the question which has occupied so many scientific minds, viz., the nature of vital force. The appearance would seem to be that the same force which in the living tissues is manifested as vitality, when the tissues are worn out and broken down appears as electricity or some other commonly known form of force.

Muscular Sense.—The muscles possess in but very slight degree, if at all, the general sensibility which belongs to most other tissues. They have little sensibility to pain. They may be pierced, cut, or even torn, without giving much pain. A peculiar pain is produced by cramp, or spasmodic contraction of a muscle. There is good evidence, however, that the muscles are compensated for the want of general sensibility by the possession of a sense peculiar to themselves, known as *the sense of weight, or the muscular sense.* It is by means of this sense that we appreciate resistance or judge of the weight of various bodies.

Rigor Mortis.—The peculiar rigidity which comes on soon after death in man and animals is supposed to be due to coagulation of the muscular fibre. It is the beginning of decomposition, and indicates the death of the muscular fibres. It is observed that in persons who die suddenly in a state of comparative health, as from accident, rigor mortis does not appear for some hours after death, and then remains for some time. In persons who die from long-continued or wasting disease, the opposite in both particulars is true.

HYGIENE OF THE MUSCULAR SYSTEM.

The muscles, perhaps, more than any other organs of the body, depend for their health upon regular, systematic, adequate, and proper exercise. By exercise, the muscular fibres are made to contract, and in doing so, the old, stagnant, venous blood is squeezed out, and new, fresh, invigorating, vitalizing blood takes its place. By this means their vital activities are quickened and their growth increased. There is evidence for believing that muscular fibres do not increase in number in the voluntary muscles; but it is certain that they increase very materially in size and in firmness, and hence in strength. The

strength of a muscle depends upon the individual strength of each of its fibres, as its strength is but the combined strength of its component parts. If each fibre becomes large, firm, and strong in consequence of use, the whole muscle becomes so; and that this is the case we have abundant evidence in the ponderous right arm of the blacksmith, which outgrows the other in consequence of constant exercise in swinging a heavy hammer. The lower extremities of a ballet dancer become developed in a proportionately large degree, from the trying exercises to which they are accustomed.

Effect of Disuse of Muscles.—Nature never attempts to maintain a useless organ, and almost as soon as an organ is not used she sets to work to demolish it; or at any rate she wastes no time in endeavoring to keep it in repair when it is not needed, or at least is not used. This is true all through the vital economy, and is nowhere more clearly seen than in the muscular system. A disused muscle soon becomes thin, pale, relaxed, weak; and after a time a change begins which is termed fatty degeneration. Nature does not think it worth while to keep so much valuable nitrogenous matter lying idle, and so she sets to work taking the muscle to pieces and carrying it away little by little for use elsewhere, depositing in place of the muscle substance little particles of fat until the whole muscle is changed to fat. This change actually occurs in cases of paralysis; and when it has been completed, restoration of the function of the muscle is impossible.

The Hindoo devotee who in blind zeal for his religion holds out his arm until the muscles shrink and shrivel up, leaving the arm but a useless appendage of the body, more dead than alive, is violating the law of nature which demands exercise for health no more than the student who shuts himself up with his books until his limbs grow lank and thin and his fingers bony with physical idleness; and the latter acts no more wisely in sacrificing himself upon the shrine of learning, than the other in deforming himself to appease the wrath or win the favor of Buddha.

How to Take Exercise.—It is not sufficient to simply take exercise indiscriminately and without reference to the object for which it is taken, the manner, time, etc. It must be taken regularly, systematically, at proper times, and in proper quantity. Perhaps we cannot do better in treating this subject practically than to ask and answer some of the most important questions relating to this matter.

1. *When is the best time to exercise?* There is a popular theory extant that exercise taken early in the morning has some specific virtue superior to that taken at any other time. After careful observation on the subject we have become convinced that this popular notion is a mistake when adopted as a rule for everybody. For many busy professional men, especially lawyers, editors, authors, clergymen, teachers, and others whose vocations keep them mostly indoors, the morning may be the only time when exercise can be taken conveniently; and if not taken at this time it is likely to be neglected altogether. Such persons, unless they are laboring under some special derangement of the health, as dyspepsia or some other constitutional malady, had better by far take the morning walk or other form of exercise than to take none at all. However, we are pretty well convinced that for most persons the middle of the forenoon is a much better time to take any kind of active or vigorous exercise. In the morning the circulation is generally weakest and the supply of nerve force is the least abundant. In the forenoon, when the breakfast has been eaten and digestion has become well advanced, the system is at its maximum of vigor; hence, if the individual is at liberty to choose his time for exercise, this should be his choice.

For poor sleepers, a half-hour's exercise taken in the evening not long before retiring will often act like a soporific, and without any of the unpleasant after-effects of drugs.

Vigorous exercise should never be taken immediately nor within an hour after a meal, and should not be taken immediately before eating. Disregard for this rule is a very common cause of dyspepsia.

2. *What kind of exercise shall be taken?* The answer to this question must, of course, vary with the individual. Exercise must be modified to suit the strength, the age, the sex, and even the tastes of the individual. As a general rule, persons who take exercise for health are apt to overdo the matter, the result of which is damage rather than benefit. For most persons there is no more admirable and advantageous form of exercise than walking; but many find walking simply for exercise too tedious to persevere in it regularly. Such will find advantage in walking in companies, provided care is taken to avoid all such questionable diversions as walking matches or any kind of exercise in which there will be a strife which will be likely to excite to excess.

Horseback riding, for those who ride well and enjoy this form of

exercise, may be of great benefit. It is not so well suited for ladies as for men, however, on account of the awkward and unnatural manner in which fashion compels them to ride. It is impossible for a lady to ride with the same degree of comfort, ease, and grace that her male companion may, on account of the one-sided way in which she sits in the saddle. In many other countries ladies ride in the same fashion as men; with them, of course, this objection does not hold.

Horseback riding is an excellent aid to digestion, and often effectually relieves habitual constipation of the bowels.

Carriage riding is worth little as a form of exercise except for very feeble invalids, for whom the gentle swaying of the vehicle and the excitement of viewing objects seldom seen may be sufficient and appropriate exercise. Riding in a lumber wagon over a corduroy road is about the only kind of carriage riding which is worth speaking of as exercise for people in ordinary health.

Skating, rowing, racing, base-ball, foot-ball, dancing, and most other exercises of the sort, are more often harmful than otherwise, because carried to excess and associated with other evils of a pernicious character. Performance upon the trapeze, boxing, and pugilistic training are open to the same objection. Calisthenics, for school-children and young students, is a most admirable form of exercise. It is also well adapted to invalids who are unable to walk more than a short distance at a time. Full directions for the use of calisthenics, or gymnastic exercises, are given in a chapter devoted to the subject. In our opinion, every family ought to be fitted out with all the conveniences for parlor gymnastics. They afford not only healthful exercise but a large amount of excellent amusement for the little folks.

The health-lift is a form of exercise too important to be overlooked. We have carefully tested this form of exercise, and believe it to be an exceedingly valuable measure for those whose employments are sedentary and whose time for exercise is limited. However, we can indorse but a small portion of what has been claimed for it by persons who have made its use and sale a specialty. Again, we have no sympathy with the course which has been taken by most manufacturers in charging an enormous price for a piece of apparatus which really costs but very little and could well be afforded for one-half the money charged. The chief benefits of the health-lift can be derived from a very simple form of apparatus which the reader will find described in the chapter on gymnastic exercises.

For the majority of persons, no form of exercise is more highly beneficial healthwise than some kind of physical labor. For ladies, general housework is admirably adapted to bring into play all the different muscles of the body, while affording such a variety of different exercises and such frequent change that no part need be very greatly fatigued. There are thousands of young ladies pining under the care of their family physician in spite of all he can do by the most learned and complicated prescriptions, for whom a change of air or a year's residence in some foreign clime, or some similar expensive project, is proposed, when all in the world that is needed to make the delicate creatures well is to require them to change places with their mothers for a few weeks or months. Let them cease thrumming the piano or guitar for a time, and learn to cook, bake, wash, mend, scrub, sweep, and perform the thousand and one little household duties that have made their mothers and grandmothers well and robust before them. We made such a prescription once for a young lady who had been given up to die of consumption by a grayheaded doctor, and whose friends were sadly watching her decline, and in six weeks the young miss was well and has been so ever since; but we entailed her everlasting dislike, and have no doubt that any physician or other person who should adopt the same course in a similar case would be similarly rewarded.

For young men there is no better or healthier exercise than sawing and chopping wood, doing chores about the house, working in the garden, caring for horses or cows, clearing walks, bringing water, or even helping their mothers in laundry work. Such exercise is light, varied, oft changing, and answers all the requirements for health most admirably. We can heartily recommend it, and from personal experience, too. We advise all young men, who can possibly get a chance, to adopt this form of exercise as being the most certain of bringing back the largest returns for a given expenditure of force of any which can be suggested. There is no gymnasium in the world which is better to secure excellent results from exercise than the kitchen, the washroom, the workshop, the woodyard, the barn, and the garden. These are nature's gymnasia. They require no outlay for special appliances, and are always fitted up for use.

Deficient Exercise by Students.—The common idea that study and brain work are harmful has chiefly grown out of the fact that students usually confine themselves too closely to their books, keep

late hours, and take as little as possible of active out-of-door exercise. There is no doubt but that the majority of students could do more work and better if they would devote at least two hours of each day to purely physical exercise. In ancient Greece, in the palmy days of that empire, physical training was considered as much a part of the necessary education of young men as their mental culture. Every inducement was offered to them to make themselves strong, vigorous, and athletic. Their schools were called gymnasia, on account of the attention given to gymnastics. The young women, too, were trained in physical exercises as well as the young men. Small waists and delicate forms, white, soft, helpless hands and tiny feet were not prized among the pioneers of civilization. The mothers of heroes and philosophers were not pampered and petted and spoiled by indulgence. They were inured to toil, to severe exercise. Their bodies were developed so as to fit them for the duties of maternity and give them constitutions to bequeath to their children which would insure hardihood, courage, and stamina in the conflict with the world to obtain a subsistence, and with human foemen in the rage of battle. The women developed by this system of culture were immortalized in marble, and the beauty of their forms has been the envy of the world from that day to this; yet no one seems to think of attempting to gain the same beauty in the same way. It might be done: there is no reason why it cannot be; but the only way is the one which the Grecian women adopted,—physical culture.

Overtraining.—The careful observation of results in large numbers of cases shows very clearly that there is such a thing as overtraining, and that excessive development of the muscular system is not only not advantageous but absolutely harmful. Trainers are not long-lived. Dr. Winship, who developed his muscles until he was able to lift over three thousand pounds, died when he should have been in his prime. The result of overtraining or excessive development of the muscular system is the weakening of other vital parts of the body. Symmetrical development is the best for health and long life. This is what we plead for, not for extremes in any direction. Let the nerves and the muscles be developed together and equably, and we shall have better results from both than would otherwise be possible. *Mens sana in corpore sano* was the motto of the ancient Greeks; and the experience of every day shows that the man with strong muscles and good digestion, with fair intellectual abilities, is the one who wins the goals to-day in the strifes for

wealth and fame and all that men seek after. "A sound mind in a sound body" is as necessary for assured success in life in the nineteenth century as when the sentiment was first inscribed upon the gates of the temples in ancient Greece.

Necessity for Unrestrained Action.—A muscle tied up is rendered as helpless as though it were paralyzed. It will be recollected that when a muscle acts it does so by swelling out in thickness, while contracting in length. From this it will be evident that if a tight band is put around a muscle in such a manner as to prevent its expansion or increase in thickness, it cannot possibly act. Hence, a fundamental requisite of healthful muscular action is entire freedom from constraint. Unrestrained action is indispensable to complete action and perfect development. When a broken arm is done up in a splint for a few weeks, upon removing the bandage it is usually found that the arm has shrunken in size; the muscles have wasted, partly in consequence of pressure, and partly on account of the enforced inaction of the muscles. The very same thing happens wherever pressure is brought to bear upon the muscular tissues. A ring worn upon a finger causes atrophy, or wasting of the tissues beneath it. By placing an elastic band around soft tissues they may be absorbed altogether, in consequence of the pressure. This action has been taken advantage of for the removal of tumors in certain parts of the body.

Evils of Tight-Lacing and Corset-Wearing.—See Figs. 52 to 55. The wearing of clothing drawn tight about the waist, either with a corset or without, is attended with most serious evil consequences. Without dwelling upon the evils which result from the forcible displacement of important internal organs and the injury to the nervous system, the digestion, and sundry other evil consequences, we wish to call attention to the fact that continuous pressure upon these parts may cause such a degree of degeneration of the muscles of the chest as to seriously impair the breathing capacity. Unused muscles waste away, as already observed; and when pressure is applied in addition, the wasting and degeneration become still more marked. This is exactly what happens with those who wear their clothing tight about the waist. This is the reason why ladies who have been accustomed to wear corsets declare so emphatically that they "could not live without them," that they feel when their corset is off as though they "should fall down into a heap."

The evidence of injury is complete; and it is so universal that few

women will venture to deny that the practice is harmful, but they try to shield themselves by declaring that they are sure *their* corset does them no harm, that it is very loose, etc., etc. We scarcely ever met a lady who would admit that *her* corset was tight, and we have had occasion to speak with hundreds of ladies on this point in making medical

Fig. 52. A waist of natural shape.

Fig. 53. A waist compressed by tight-lacing.

examinations. We read the other day in a newspaper of a young woman who actually broke a rib in the attempt to gain another half-inch on her corset string. She well deserved the accident, no doubt; but the chances are ten to one that she would assert in the most positive terms, if expostulated with about the matter, that her corset was "quite loose," and to demonstrate the matter would show you how much more she could pinch up when she tried, or something of the sort. The fact is, ladies do not really know when their clothing is tight about the waist and when it is loose. The tissues have been so long under pressure that they have lost a good share of their sensibility, and clothing really seems loose to them which to a man would be so uncomfortably tight as to make him utterly wretched.

Pantaloons made tight at the top are as harmful as tight dresses, as was well shown in the Russian army some years ago, when the evil of wearing the pantaloons held up by a belt about the waist became so serious among the soldiers as to require interference on the part of the government. The men had become unable to endure marches of any

distance; but upon being compelled to wear suspenders for the pantaloons, they speedily recovered.

Elastics.—The elastic bands worn about the leg to keep the stocking in place, and sometimes used upon the arms to hold the sleeves up, are more harmful than is usually imagined. The long stockings worn by females bring the elastic just above the knee, where the large blood-vessels of the limb come near the surface and are in position to be compressed against the thigh bone in such a way as to impede the circulation. It is not to be wondered at that under these circumstances, in addition to the evil of thin stockings, and thin, tight shoes, there should seem to be a necessity for artificial calves, which we are informed on credible authority have actually been employed. The stockings, as well as the other articles of clothing, should be suspended from the shoulders either by means of separate suspenders or by attachment to a waist with broad shoulder-bearings.

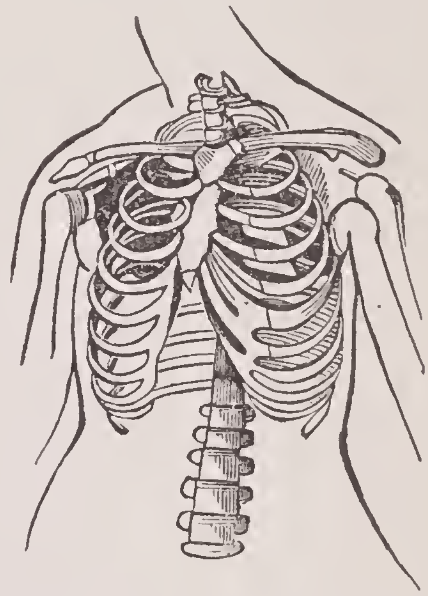


Fig. 54. The ribs in their natural position.

Pull-Backs, Low Shoulders, etc.—The following on this subject we quote from "Evils of Fashionable Dress":—*

"Although the corset is the chief offender in constraining the healthy activity of the vital organs of the body, there are other modes of dress which deserve attention on account of their interference with some of the bodily functions. When the leaders of fashion decreed that the previously indispensable crinoline must be discarded, the sensible part of the world rejoiced, thinking that Dame Fashion was really about to reform her ways. But such hopes were dashed to the ground when the present fashionable style of dress appeared. Formerly, fashionable ladies sailed along the streets like animated balloons, monopolizing the whole walk with their wide-spreading skirts. Now they have reached the opposite extreme, and we see them wriggling along like competitors in a sack-race. Indeed, it is a marvel how that locomotion is a possibility, so greatly hampered are

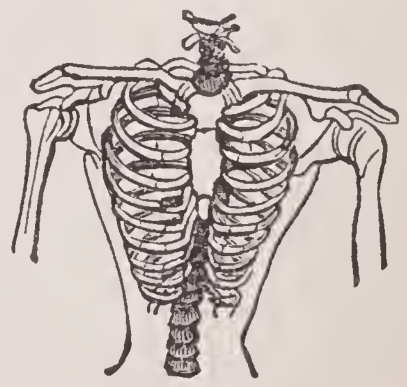


Fig. 55. Shows the distortion of the ribs produced by corset-wearing.

* Good Health Pub. Co., Battle Creek, Mich.

the limbs by numerous heavy skirts drawn tightly back and fastened at the sides. Anything like graceful ease in walking is impossible. A Chinese wriggle is the result of the best attempt.

"The motions of the arms are curtailed to an almost equal extent by the fashion of the garments about the shoulders. They are so made that it is next to impossible for the wearer to extend the hand an inch above the head. The arms are actually pinioned. Why not have the shoulders of ladies' garments made like those of men, which allow perfect freedom of motion to the arms? Some of the more recent fashions are adopting this style."

Tight Shoes.—We have already said so much on this subject in connection with the hygiene of the bones that we scarcely need add anything here, except to say that the muscles of the feet suffer equally with the bones, perhaps more seriously, being more soft and yielding. We cannot find words to express our views of this foolish and absurd custom. There seems not the slightest shadow of excuse for it, except that Fashion dictates that woman must have a small foot; and if Nature has made such a terrible blunder as to give her one of decent size she must be tortured for the mistake for which she is not responsible, during the period of her natural—or rather her artificial—life. Fashion dictates a similar mandate in China, and the amount of suffering which the fashionable young women of that country are obliged to endure is even greater than in this country. Perhaps we cannot better impress our readers with the absurdity of this really barbarous fashion than by quoting from an interesting work entitled "Oriental Women" the following graphic description of the extent to which the practice is carried in China:—

"It is supposed by many foreigners that this curious compression of the feet is accomplished by means of wooden or iron-bound shoes placed upon the feet in infancy, effectually dwarfing them by preventing their growth altogether. But this is by no means the case. It is next to an impossibility for a foreign gentleman to secure the privilege of examining a foot thus deformed; but after more than a week of the most skillful diplomacy, in all of which I was aided and abetted by Miss Lucy H. Hoag, preceptress of the mission-school for girls in Kiu-Kiang, I succeeded in persuading a girl about fifteen years of age to allow me to be present when the gay covering was removed from her foot; afterward in Shanghai, by the liberal use of money, an el-

derly woman of the small-footed class was persuaded to gratify my curiosity by removing the bandage from her foot; and from the knowledge gained on those occasions and afterward I will briefly describe the method of 'making the foot,' as it is called.

"The binding is rarely, if ever, commenced before the child is five years, and in most cases not until she is six or seven years old. This delay is to allow the limbs a vigorous start and growth, and the girl to learn how to walk firmly. The operators are usually women who make this their business, although frequently the mother, or some other female member of the household, takes the matter in hand. In the first place, all the toes, excepting the great toe, are folded down under the foot, the fleshy part of the heel is forced downward and forward, and a bandage (consisting of a strip of colored muslin four or five feet long and three inches wide) is wound back and forth in a figure of eight, over the folded toes, along the length of the foot, across the instep, and around the heel, pressing that toward the great toe to shorten the foot. The bandage is wound snugly at first, and then tightened a little at each succeeding operation. This gradually throws the instep up, and virtually breaks it, so that when the bandage is removed the front part of the foot may be moved like a door upon its hinges. Under this process the foot becomes attenuated until it is merely a mass of bones covered with tendons and skin. The development of the muscles of the calf is also checked, and the leg tapers from

Fig. 56. Outline of Chinese lady's foot and slipper, showing effects of bandaging.

the knee downward, and the entire limb loses its elasticity, although no excessive weakness is observed. How the circulation is kept up through the extremities is more than I can understand.

"In the course of six or eight years, if daily attended to, the elongated bone of the heel, which is about all that is left of this part of the foot, is brought within a very few inches of the great toe; the broken instep and folded toes are bound together with the ankle in an ugly bunch bulging outward above what seems to be the foot, and the great toe and the heel alone are thrust into the little embroidered shoe, and it is pronounced a perfect lady-foot. The heel is usually an inch or more higher than the toe, and a block of wood is placed in the back part of the shoe to support it. This gives the woman the appearance of walking upon her tiptoes, as she wriggles along, stepping with nervous rapidity, and throwing out her arms to balance herself. A lady with very small feet is obliged to use a cane in walking, or to rest her hand upon the shoulder of a servant, which is a mark of especial gentility.

"The wide and embroidered trousers conceal the unsightly bunch above the shoe, and the uninstructed observer supposes that he is looking upon a tiny but perfectly formed foot. The length of the shoe is really a mere matter of taste. The most fashionable length is, I think, about three inches, although I have a pair in my possession, once worn by a woman in Foochow, which are but two and one-half inches long on the bottom. Of course, so far as any heavy work is concerned, small-footed women are useless; and the housework in families where the women have small feet is always performed by males, or by female servants who have natural feet.

"At first the operation of bandaging is very painful. The bandage is removed every morning; the foot is cleansed, carefully inspected, and then rebound. Of course, before the foot is utterly 'dead,' as it is termed, the quickening of the circulation when the bandage is removed and the severe compression when it is again applied, cause excruciating pain. In the early morning hours the traveler, in moving about a Chinese city, will hear from almost every house the cries of little girls undergoing their daily torture.

"A well-known missionary gives the following illustration:—

"'I remember being greatly distressed one day by the crying of a child: "O auntie, auntie, *don't* do so, it hurts; it hurts *so* much!" And then followed a long, quivering, sobbing "O-o-oh!" I tried not

to mind it at first, and kept on with my writing for a little while; but I could n't stand it very long,—the sobbing was too piteous. So I laid down my pen, put on my hat, and went round the corner into the alley from which the sounds came. It was dirty enough and narrow enough, I can assure you; but that was nothing. I only wanted to ascertain what could be the cause of this most pitiful outcry, and what it was that "auntie" was doing. So I pushed open the door that led into one of the court-yards, and there I saw how the matter stood. On a high bench, with her feet dangling half-way to the ground, sat a little girl about five years old, her face swollen with crying, and the tears pouring down her flushed cheeks; and near by, seated in a chair, was that dreadful "auntie," a fat, middle-aged woman, who held one of the child's feet in her hand, while the other foot was hanging down bandaged very tight, and looking more like a large pear, tied round with blue cotton cloth, than a natural-shaped foot. There the old auntie sat, with one little bare foot in her hand, looking at it first on one side and then on the other, and particularly examining the parts where the little toes had been turned under and compressed by the bandages which had just been removed. She found these parts full of cracks and sores, and into these what do you think she put? *Powdered saltpeter*, to keep the sores from mortifying; and then she bound up the little foot again as tight as she could, and left the poor little sufferer, with streaming eyes and dangling feet, still sitting on the bench!'

"Girls often grow thin and spiritless during the first year after binding is begun. Often the skin cracks or (just over the instep) it bursts, and severe disease sets in, and not infrequently mortification or gangrene ensues; and as amputation is regarded as very dishonorable, and is, therefore, not allowed, of course the little sufferer soon dies.

"When three or four years have passed, if the operation has been carefully performed, the foot becomes, so far as feeling is concerned, lifeless, and ceases to give pain. But, all through life, the bandaging must be continued, to keep the foot in shape, and to enable the woman to walk at all. Unbandaged, the foot would have no firmness,—it would be a mere powerless mass upon the limb, with which it would be impossible to move. With the foot firmly bandaged, some of these poor creatures mince along at quite a respectable rate of speed, and strange as it may seem, some of them will even walk ten or twelve miles in a day on their way to and from some especially sacred temple, or in making visits to their friends.

"Notwithstanding the severe pain resulting from this bandaging at first, mothers insist upon it, and little girls are often quite anxious to have it begun; for it is the fashion, and, according to the average female estimate in all lands, a little suffering, more or less, is of no consequence when contrasted with the disgrace of being 'out of fashion.' Of course, the little girls are not always under the immediate eye of their mothers; and when, for a moment, the pain overmasters their pride, they will slyly loosen the bandage; but the fault is soon discovered, and the relieved member unmercifully brought back to its cruel bondage.

"So far as I can learn from those most familiar with the facts, compression of the feet is more inconvenient than dangerous, either to life or health; and intelligent natives have frequently assured me, with all that superior wisdom which an educated Chinaman knows so well how to assume, that they did not regard it as half so pernicious as the custom our American ladies have at times adopted, of compressing their waists, since the former, at the worst, only endangers the individual, while the latter entails feebleness and suffering upon posterity.

"Some travelers in China profess to be greatly pleased with what they call the dainty little feet of the ladies, and go into ecstasies over their exquisitely wrought shoes; but to me, especially after I became familiar with the *modus operandi*, it was a hideous and repulsive deformity, all the more offensive since it was self-imposed. No amount of sentiment could reconcile me to the sight of those poor cripples hobbling along in momentary danger of falling,—the very picture of degraded helplessness. Perhaps in justice I ought to add, that some few Chinamen of advanced ideas whom I met, professed to regard this custom as useless and wrong; but even while they were ready to admit its evils, they were no less emphatic in the opinion that there is no help for it. Custom is a *law*, which no one dreams of violating."

Bad Positions.—Certain parts of the muscular system suffer seriously from the results of bad positions assumed in the different attitudes which may be taken in lying, sitting, standing, and walking; to these we wish to call especial attention.

Bad Positions in Sleeping.—As we spend one-third of our time in bed,—at least most persons should do so,—it is of great importance that the right position should be assumed, so that no injury may be received through prolonged constraint in an injurious position. Another fact of importance which is worthy of consideration here is that the process of repair goes on much more rapidly during sleep than at other times,

and since the greater share of deposit of new material takes place at this time it is obvious that any evil arising from an incorrect attitude will be rendered more or less permanent, the individual growing out of shape during sleep.

We regard the old-fashioned bolster, not yet out of fashion we are sorry to say, as a most injurious article. When surmounted by a pillow, as it invariably is, the position designed for the head is elevated so high that the sleeper cannot possibly put himself into a physiological position if he attempts to use them. If he lies upon his back, he is sitting half upright, and his spine is curved posteriorly. Fig. 57. If he lies upon either side the spine will be bent at a dangerous angle. Fig. 58. We have no doubt that thousands of cases of lateral curvature of the spine have been produced by sleeping with the head too much elevated.

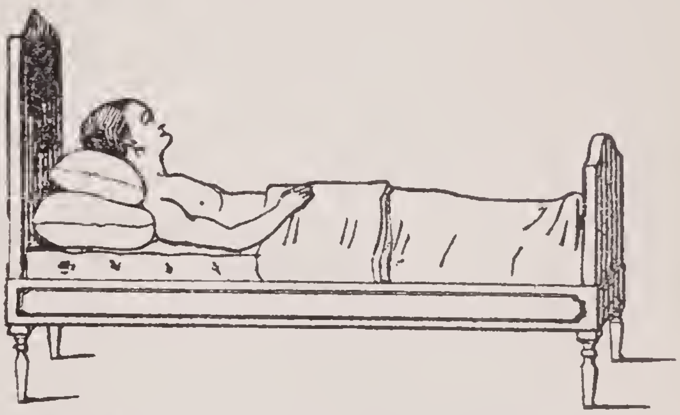


Fig. 57. Improper position in sleeping.

A correct attitude in sleep is with the head and spine as nearly as possible parallel with the central line of the body. If the individual lies upon the back, no pillow at all, or a very thin one at most, should be employed. If he lies upon his side, a somewhat thicker pillow may be used, but only of sufficient thickness to raise the head to the axis of the body. Under no circumstances should bolsters be employed. The side seems to be the most natural position in which to lie in sleeping, and the right side should be chosen by preference, especially by those who eat late before retiring, as this position favors the passage of the food from the stomach through the pylorus.

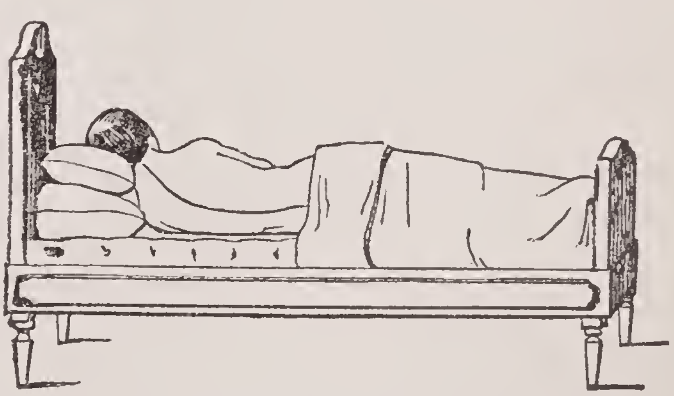


Fig. 58. Improper position in sleeping.

Improper Attitudes in Sitting.—This subject we have already considered in part under the head of Hygiene of the Bones, and would refer the reader to the remarks there made. It must be added, however, that the distortions of the spine produced by improper positions in sitting are only in part due to the changes produced in the cartilages of the

spinal column, which have been pointed out. At the same time that changes in the cartilage discs are being made, changes are also taking place in the numerous muscles of the spine. When the body is bent out of its proper shape, while certain muscles are contracted, others are

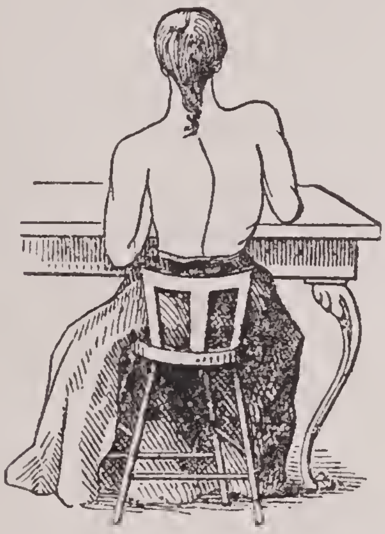


Fig. 59.

Fig. 60.

stretched beyond their natural length. If the tension is maintained but a short period, the natural elasticity of the muscle restores it to its natural length again, and so brings the body into proper position; but if it be prolonged, the tonicity of the muscular fibres is in some degree lost. They give up their elasticity and become abnormally lengthened without power to return fully to their natural position. At the same time, the muscles which are contracted while the curved position is maintained become by the exercise stronger than their antagonizing muscles, which are at the same time being weakened by want of use and abnormal stretching. Thus the evil results are doubled, and the curvature which was at first a mere temporary evil becomes permanently fixed in the body by unequal muscular contraction.

Fig. 61.

Figs. 59, 60, 61, 62, and 64, show positions which are very commonly assumed by students and others. The figures explain themselves at a glance. Many other bad positions are common, not a few of which are undoubtedly due to the improper construction of chairs, sofas, school seats and desks. In many instances in schools, large students are placed in seats which are too low for them (see Fig. 60), and which require or at least strongly incline them to lean forward while engaged in their studies, making them round-shouldered and narrow-chested. It

is probable, however, that the opposite error is much more common, and is certainly much more injurious, viz., placing small students in seats which are too large and too high for them. When this is done, several evils result. The feet not being properly supported, the weight of the limbs constantly drags upon the spine, and requires that its muscles be kept con-

Fig. 62.

Fig. 63.

stantly in contraction, and at a disadvantage. The desk being too high, in writing the arm must be lifted so high as to unavoidably produce curvature of the spine by elevation of the shoulder. Other evils are also almost certain to follow, among which are disturbances of vision from holding the book too near the eyes, disturbance of the circulation, especially in the lower extremities, due to unnatural pressure on the under side of the limbs, and nervous affections from the unnatural strain upon the sensitive spine from the want of support to the limbs.

Another evil very common in the construction of seats for school-children is placing the desk too far away from the seat (see Fig. 64), thus not only inviting but actually obliging the pupil to lean forward in writing, drawing, or ciphering. This evil is of no small consequence, and we are glad to see that it is being remedied by some manufacturers. Still another common failure is neglect to so shape the backs of seats as to enable them to support the spine at its weakest point. This latter evil is probably as great a cause of curvature as any. The spine becomes tired from want of proper support, and the pupil leans over to get relief. We are glad to know that these difficulties, which have been recognized for several years, but have not been remedied on account of the failure of manufacturers to adapt their seats to the physiological wants of those who were to occupy them, need no longer

exist on this account. An ingenious clergyman, who is also a professor in an educational institution, has, after several years of patient labor, succeeded in producing a seat which seems to meet all the requirements of a perfect seat in a manner in which they have never been met before. It has been already introduced into hundreds of schools, and gives universal satisfaction. We present in Fig. 65 a view of this seat.*

Fig. 64. This cut shows the distorted and unhealthful position which a student is almost compelled to occupy by the old-style school seat.

Students, and others as well, often assume most improper attitudes while pursuing their studies at their rooms, tilting their chairs back and placing the feet against the wall, upon the top of the table, or in some other elevated place. Such a position cannot be long maintained without discomfort, and discomfort is simply an admonition of nature to take a different attitude, to change the position.

As a rule which may be universally followed, we know of no better than the simple one, "sit gracefully." A graceful position is a natural one, and will be productive neither of inconvenience nor injury. We grant that there are great difficulties in the way, since very few chairs are constructed on physiological principles ; but this is a matter which should receive attention in purchasing furniture. It is possible to obtain

*Any one who desires further information concerning it can obtain full particulars by addressing the inventor, Eld. U. Smith, Battle Creek, Mich.

chairs which are reasonably correct in construction. The principal points which need to be looked at are the following:—

1. A chair should be so constructed that it will properly support the back, not by one or two slats placed crosswise, but by a uniform curve, corresponding as nearly as possible with the natural curve of the spine. The whole spine should be supported without requiring a person to

Fig. 65. This is a representation of the Automatic School Seat, which encourages a correct attitude.

throw the shoulders forward in order to bring the lower or middle part of the spine in contact with the back of the chair.

2. It is also important that chairs should be of proper height, so that the weight of the limbs may be supported by the feet set squarely upon the floor instead of hanging upon the front edge of the chair. Nearly all chairs are made too high, if not for the adult persons in the family, for nearly all the younger members, who most of all need seats properly constructed. There should be chairs of different heights for different members of the family; and the importance of the matter is sufficient to justify the incurment of the expense necessary to secure each member of the family against injury from this cause.

While we are by no means inclined to be ultra upon the subject, we must enter a word of protest against the too common use of rocking-

chairs. As usually constructed they induce an improper attitude in the occupant, one which limits the action of the lungs and produces roundness of the shoulders. We seldom sit in a rocking-chair for a half-hour without finding it necessary to get up and walk about, expanding the chest and filling the lungs to relieve the feeling of oppression which results from the confinement of the chest. We have frequently observed in patients suffering with lung troubles a careful avoidance of rocking-chairs, and upon making inquiry have found that what we say is true. They avoided the rocking-chair because with their diminished lung capacity they could not breathe well while sitting in it.

While the rocking-chair is undoubtedly a comfort to thousands, we have no doubt that on the whole it has been a curse to the race, especially to womankind. We may have easy chairs, made as soft and luxurious as possible ; but let them be made in accordance with physiological principles. Art has made the models for chairs rather than nature. If we would follow art less and nature more in numerous ways we should be vastly better off.

Fig. 66. Improper position in standing, the shoulders being thrown forward.

Bad Positions in Standing.—See Figs. 66 and 67. While there need not be so much said on this subject as on the former, a few points deserve attention. It should be remembered that the muscles are required to act while we are standing as well as when walking or making active movements. It requires a constant exercise of a large number of muscles, particularly those of the trunk, to keep the body erect, to prevent it from toppling over. Hence it is important, especially for those whose occupations require a standing position much of the time,—as clerks, accountants, bank cashiers, etc.,—that correct attitudes should be preserved, so that the muscles may

Fig. 67. A correct position in standing.

act properly. It is a very common practice with many to throw the weight wholly upon one foot, alternating with the two feet. When this is done, the spine is curved, and parts are thrown greatly out of their natural position. The weight may be easily alternated without so great changes; and when this is done, all the benefit which can be derived from any change of the sort is obtained. The rule should be to always preserve the body erect, the shoulders well thrown back, the chest well expanded, and the spine as straight as nature has made it. It is possible to go to an extreme even in this, but such a defect is so rare that we need not utter any warning against it.

How to Walk.—It may seem at first ridiculous to pretend to teach grown people how to walk, as though they had not learned this in infancy. But we are willing to venture the assertion that not one person in twenty knows how to walk well. How few people are there who do not feel slightly embarrassed when obliged to walk across a large room in which are many persons seated so as to observe well each movement! How many public speakers there are who appear well upon the platform so long as they remain standing still, or nearly so, but who become almost ridiculous as soon as they attempt to walk about. Good walkers are scarce. As we step along the street, we are often looking out for good walkers, and we find them very seldom. What is good walking? We answer, Easy, graceful, natural walking. Nearly all the good walkers there are, will be found among gentlemen, since fashion insists on so trammeling a woman that she cannot possibly walk well, can scarcely make a natural movement, in fact. To walk naturally, requires the harmonious action of nearly every muscle in the body. A good walker walks all over; not with a universal swing and swagger, as though each bone was a pendulum with its own separate hanging, but easily, gracefully. Not only the muscles of the lower limbs, but those of the trunk, even of the neck, as well as those of the arms, are all called into action in natural walking. A person who keeps his trunk and upper extremities rigid while walking, gives one the impression of an automaton with pedal extremities set on hinges. Nothing could be more ungraceful than the mincing, wriggling gait which the majority of young ladies exhibit in their walk. They are scarcely to be held responsible, however, since fashion requires them to dress themselves in such a way as to make it impossible to walk otherwise than awkwardly and unnaturally.

We cannot attempt to describe the numerous varieties of unnatural gaits, and will leave the subject with a few suggestions about correct walking.

1. Hold the head erect, with the shoulders well drawn back and the chin drawn in. Nothing looks more awkward and disagreeable than a person walking with the head thrown back and the nose and chin elevated.

2. Step lightly, with elasticity—not with a teetering gait—setting the foot down squarely upon the walk and raising it sufficiently high to clear the walk in swinging it forward. A shuffling gait denotes a shiftless character. But do not go to the other extreme, stepping along like a horse with "string halt." A person with a firm, light, elastic gait, will walk much farther without weariness than one who shuffles along. A kind of measured tread or rhythm in the walk also seems to add to the power of endurance, though, for persons who have long distances to travel, an occasional change in the time will be advantageous.

3. In walking, do not attempt to keep any part of the body rigid, but leave all free to adapt themselves to the varying circumstances which a constant change of position occasions. The arms naturally swing gently, but not violently. The object of this is to maintain the balance of the body, as also by the gentle swinging motion to aid in propelling the body along.

Correct walking should be cultivated. It ought to be taught along with the arts and sciences. In our military schools it is taught; but these schools can be attended by but few. Invalids especially should take great pains to learn to walk well, as by so doing they will gain more than double the amount of benefit they will otherwise derive from the exercise.

Relation of Food to the Muscles.—While this is not the proper place for a complete account of the subject of food as related to the muscles, we may well notice a few points. Experiments show very clearly that the muscles are wasted by work and exercise of all kinds requiring muscular effort. Equally careful and reliable experiments have determined the fact that the muscles need for their support, certain elements of food more than others; these are the nitrogenous elements. The muscles are themselves nitrogenous substance, and hence they require elements of the same character. It is as impossible to nourish the muscles or supply them with force from starch, sugar, or

fat, as it would be to make a brick house out of wood or straw. They need gluten, albumen, fibrine, caseine, and similar nitrogenous elements. It is not necessary to eat animal food to obtain these elements, though they are contained in greatest abundance in animal tissues. Vegetable food, such as oatmeal, peas, beans, and the unbolted meal of all the grains, contains a large proportion of this class of food elements. It is observed, in fact, that in the meal of wheat we have exactly the right proportion of all the food elements necessary to nourish the body and maintain it in health. This fact is also established by the dietetic customs of various nations who use little or no animal food with the exception of milk, and that in moderate quantities. Thousands of persons have been muscle-starved from the attempt to live upon fine-flour bread, which contains very little more than starch, and has been proven by experiment to be incapable of supporting the life of a dog.

The athletes of ancient Greece and Rome were not reared on fine-flour bread; and it is equally worthy of notice that prize-fighters, wrestlers, and all persons in training for feats requiring the highest physical development, avoid fine-flour bread, and make graham bread, oatmeal, cracked wheat, and such food, a large proportion of their diet. Thus fully does experience corroborate the conclusions of theory in this matter.

THE NERVOUS SYSTEM.

ANATOMY OF THE BRAIN AND NERVES.

The structure of the nervous system is the most complex and delicate of any part of the body. Many portions of it, indeed, are not yet perfectly well known, although many physiologists have devoted their whole lives to careful study of this part of the human organism. We shall not attempt to give any except the most thoroughly established facts, devoting little space to the consideration of complicated and disputed questions connected with the subject.

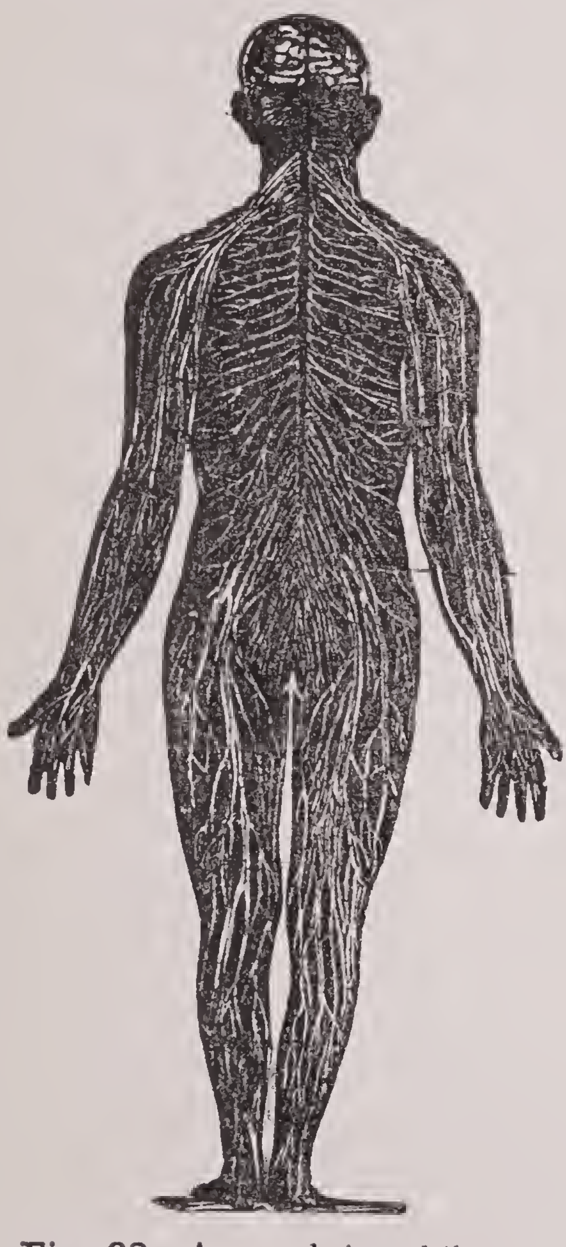


Fig. 68. A general view of the nervous system.

Structure of Nerve Tissue.—The microscopical characters of nerve tissue we have already considered. We found that there are two distinct elements in nerve tissue, cells and fibres. The essential element of both of these we found to be the same, the central part of the fibre being but a continuation of the cells, both being composed of the great basis of all forms of living matter, protoplasm.

These two elements of the nervous system are differently distributed in the body. The cells are collected in groups in the central parts of the body, which are termed *ganglia* while the nerve fibres, associated in bundles, ramify to every part of the body. So completely is the whole body permeated by these delicate filaments occupied in transmitting sensations and volitions, that if all the other tissues were removed, the nerves would still present an exact outline of the body

Divisions of the Nervous System.—Considered from the standpoint of function, the nervous system is divided into two classes, each of which has a distinct work to perform; viz., the *cerebro-spinal* system, and the *organic* or *sympathetic* system. The first mentioned is that with which we have most to deal, because this is the one which chiefly distinguishes man and animals from vegetables, and the higher functions of which distinguish man from lower orders of animals. The second class or system of nerves presides over the nutritive functions of the body, the processes of growth and repair, excretion, secretion, etc., which are sometimes termed the *vegetative* functions because of their close analogy to similar functions in vegetables, although in the latter class of existences there is nothing analogous to a nervous system.

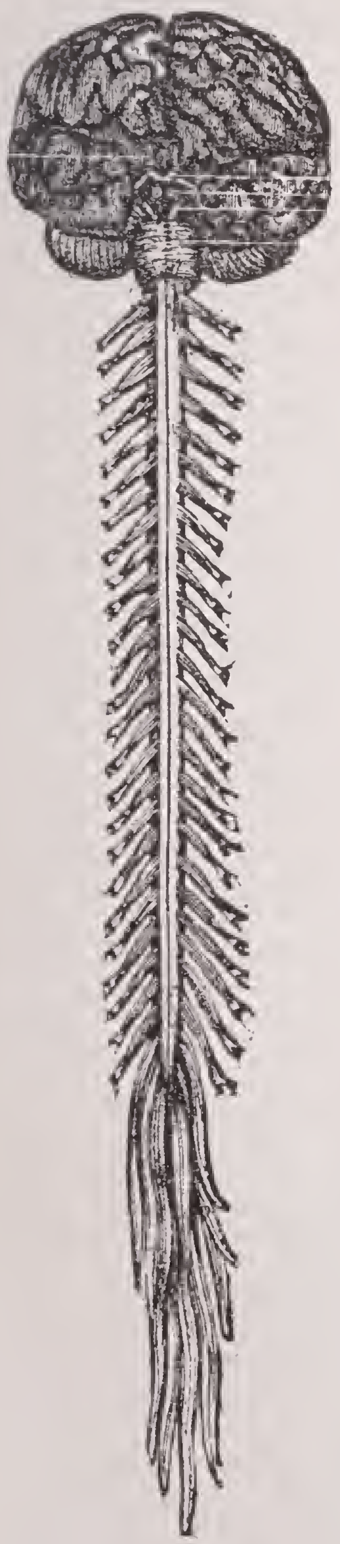


Fig. 69. The Brain and Spinal Cord.

Fig. 70. A view of the upper surface of the brain, exposed by turning back the scalp and removing a portion of the cranium.

Description of the Cerebro-Spinal System.—The cerebro-spinal system is made up of ganglia and nerve trunks. The ganglia, or groups of cells, are chiefly to be found in the skull and spinal canal, constituting the brain and spinal cord, the central axis of this system, the nerve trunks emanating from these two great centers and extending to all parts of the body. See Fig. 69.

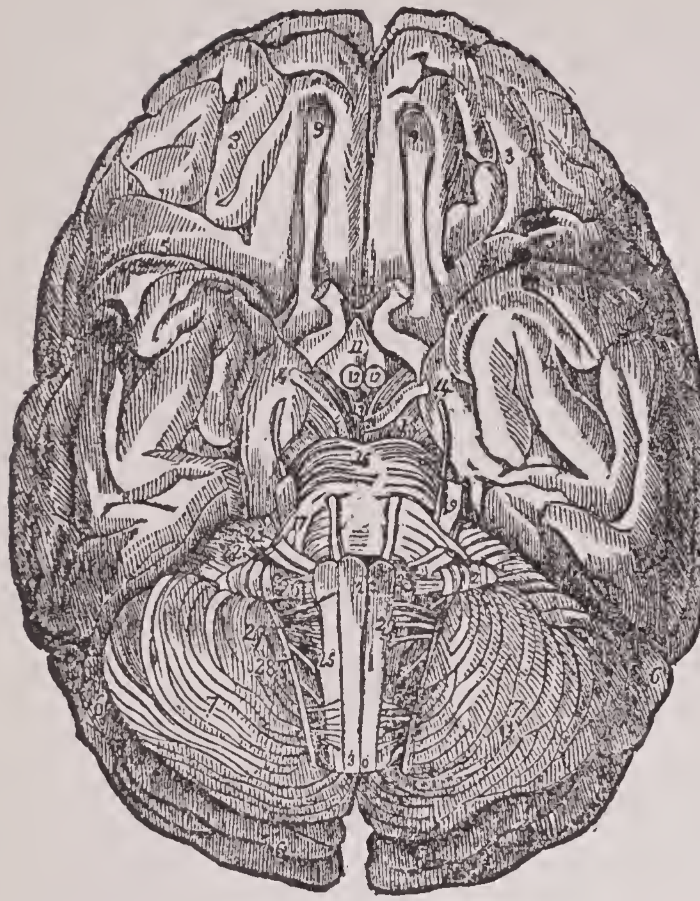


Fig. 71. A view of the under surface of the brain, showing the origins of the several pairs of nerves.

Structure of the Brain.—See Figs. 70–73. The brain is the largest mass of nervous matter in the body, filling the entire cranial cavity. Its weight is about forty-nine and one-half ounces in males, and forty-four ounces in females. It is inclosed by two membranes, the outer of which is closely applied to the inner plate of the skull, and from its toughness called the *dura mater*. This membrane abounds in blood-vessels, from which nourishment is supplied to both the brain and the skull, and by means of which the blood-supply of the interior and exterior of the cranium is in communication. Next the brain is another delicate membrane chiefly made up of blood-vessels which run down into the substance of the brain. Between this membrane and the *dura mater* is still another membrane so delicate in its structure that it has received a name which describes it as being like a spider's web.

The membranes of the brain divide it into a larger and a smaller portion. The larger portion, located in the upper and front part of the skull, is called the *cerebrum*; the smaller portion, located in the back and lower part of the skull, is called the

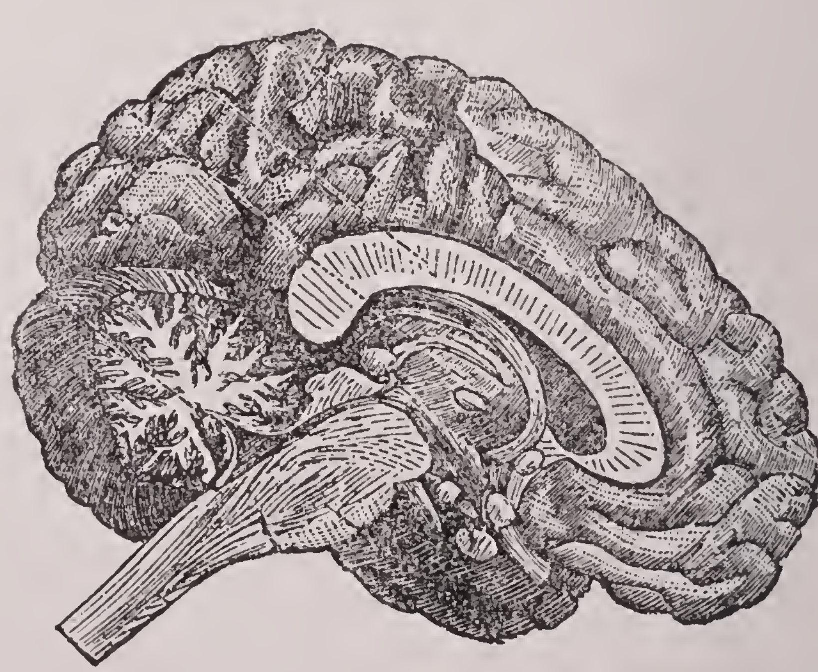


Fig. 72. The left half of the brain, showing the convolutions of the cerebrum, one lateral ventricle, the *arbor vitæ* of the cerebellum, etc.

cerebellum, or little brain. Each of these principal portions of the brain is subdivided by a fold of the membranous coverings into two lateral halves, each of which furnishes nerves to the opposite half of the body.

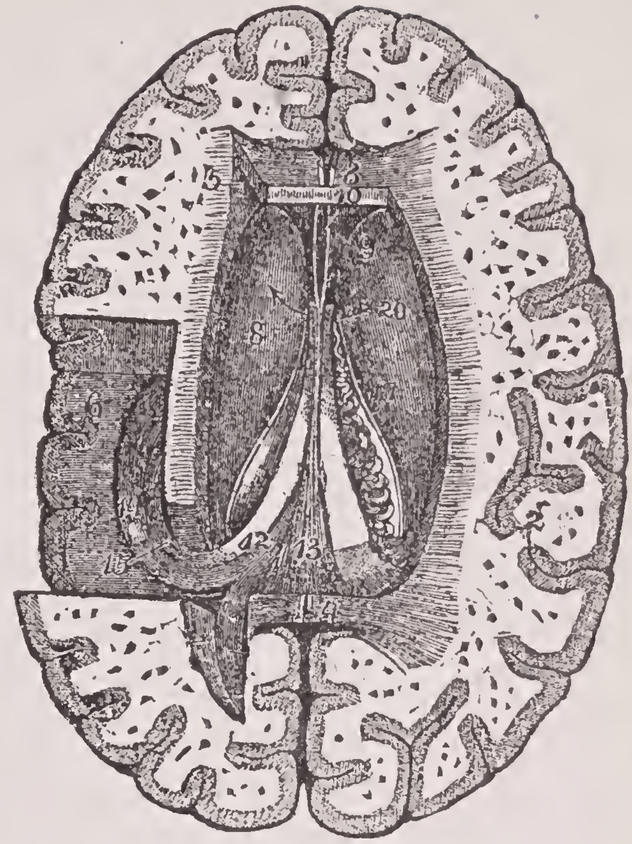


Fig. 73. A horizontal section of the brain through its middle portion, showing the relation of the white matter to the gray, with many other points of interest.

When the membranes of the brain are removed, its surface is found to be marked by numerous and quite deep depressions, which are due to the convolutions or foldings of its outer layers. The gray color of the mass is also noticeable. When cut, it is found that the gray substance extends but a little way into the mass of tissue, the central portion being white. Examination with a microscope shows that the gray substance is composed of nerve cells, while the white portion is made up of fibres, which are connected with the cells.

Fig. 74. A view of the Cranial Nerves, with their points of origin in the brain.

At the base of the brain, or its under side and central portion, are found a number of collections of gray matter or nerve cells, called the *central ganglia* of the brain.

At the lowest portion of the brain, just at its junction with the spinal cord at the *foramen magnum,* is a rounded body, known as the

medulla oblongata, which may really be considered as the enlarged upper end of the spinal cord.

In the central portion of the brain is found a curious little organ about as large as a pea, the *pineal gland,* which the great philosopher Descartes supposed to be the seat of the soul. It is now known to be simply a gland.

From this exceedingly brief description it will be seen that the brain is really a collection of ganglia within the skull, and consists of several distinct groups of cells. Each group has its particular function to perform, its particular part of the work of the vital economy to control or direct. From each one go out nerve fibres which terminate in different ways, according to the functions to be performed.

The Spinal Cord.—The spinal cord, or marrow, as it is sometimes called, is really a continuation of the brain down through the spinal canal. It extends through the whole length of the canal, and at its lower extremity spreads itself out like the tail of a horse, whence it is in this region called the *cauda equina.* The spinal cord is really a series of cell groups, or ganglia, ranged one above another, but so closely joined together as to make them practically inseparable. Like the brain, the cord is invested by membranes designed for its protection and nourishment. Like the brain, also, it is divided into two lateral halves, each half being further divided into anterior and posterior columns. All along its course the cord sends off branches, which have two roots, one of which arises from the anterior column, and the other from the side of the cord, branches being sent off symmetrically from both sides.

The Cerebro-Spinal Nerves.—The nerve branches which are sent out by the brain and spinal cord number forty pairs in all, of which nine pairs originate in the brain, and thirty-one in the spinal cord. See Figs. 74 and 69.

The thirty-one pairs of nerves which are derived from the spinal cord are distributed chiefly to the trunk and extremities, all parts of which they supply with nerves of sensation and of motion. The nine nerve branches from the brain, arising chiefly from the central ganglia at its base and from the *medulla oblongata,* are distributed to the face, the organs of special sense located in the head, and the vital organs of the chest and abdomen.

The manner in which nerves and nerve cells are connected is now pretty well understood, though it has been but recently that the exact

mode of connection has been determined. It will be recalled that nerve cells are provided with peculiar appendages, some possessing but one, others two, three, or even as many as a dozen or more. It appears from careful investigations that have been made of this subject that these poles or branches are for the purpose of connecting together individual cells; and also, that nerve fibres are simply prolongations of these same appendages. By this means the minute cells of the brain and spinal cord are actually extended into the most remote portions of the body; and the millions of cells which make up the gray matter of the brain and cord are connected by the same means.

Fig. 75. A view of the Sympathetic or Organic Nervous System.

The Sympathetic or Organic System of Nerves.—Fig. 75. This system is made up of a series of small ganglia found in the head and on either side of the spinal column within the cavities of the trunk. The ganglia are all connected by small fibres, so that they are sometimes spoken of as being a single nerve, *the great sympathetic.* Their fibres follow the blood-vessels in great numbers, starting with them as they go out from the heart. A large collection of the nerves of this system, found in the abdomen just back of the stomach, is known as the *solar plexus*. This system is closely con-

nected with the cerebro-spinal system of nerves by means of communicating branches.

General Properties of Nerves.—Nerves possess, during life, the power to do two things: to conduct nerve force, and to conduct impressions received from without. Both these properties are not possessed by the same nerve fibres at the same time. For doing the two kinds of work there are two classes of nerves. They do not differ in the least in structure, but totally in function. One carries impressions into the brain and spinal cord; the other transmits nerve force in the form of impulses outward. As there are many varieties of impressions to be received, there are several kinds of nerves which have power to transmit impressions only of one certain kind. These are called nerves of special sense. This property of nerves is known as nervous irritability. Each nerve of special sense possesses only its own kind of irritability. For instance, the nerve of sight transmits impressions of sight, but not of hearing, smell, taste, or any other kind of impression. So with each of the others. The nerves which travel outward from the nerve centers end in the muscles,—where they are called *motor* nerves,—in membranes, glands, and in all parts requiring the aid or control of the nerves.

PHYSIOLOGY OF THE BRAIN AND NERVES.

The chief organ in the nervous system is the brain. This is the great center from which emanates the nerve force which vitalizes and energizes every part of the body. It is the seat of government in the vital domain, the nerves being its servants through which it receives information of the external world, and by means of which it is able to execute its mandates in all parts of its province, even extending beyond itself and the limits of the body, and operating upon external things through the medium of its instruments.

As before stated, the brain is made up of a series of ganglia, each of which has special duties to perform. We can only understand the functions of the brain as a whole by studying the functions of each of the separate groups of cells which compose it. This has been done with the greatest care, and very recently results have been obtained which throw great light on this hitherto most complex and mysterious subject. So far as we know, these results have not yet been embodied in any treatise on the subject, being only to be found in sci-

entific periodicals. An eminent writer* in a leading English scientific magazine, the *Nineteenth Century*, has summarized these late results so admirably and succinctly that we cannot do better than to quote a portion of his article, as follows:—

"The most important step in modern research, and which may be said to have ushered in a new period in our knowledge of brain function, was the application of electricity to the hemispheres of the brain of living animals, and the observation of the effects caused by such stimulation. The first successful experiments of this kind were made by two German observers, Fritsche and Hitzig, of Berlin, who were soon followed by Ferrier in this country. A secure base was thus given to one of the most important doctrines of the present day, viz., *the localization of the several cerebral faculties;* and if vivisection had done nothing else for science, it would simply on account of this have a claim on our gratitude. But vivisection is only one of the means which have been employed toward the elucidation of our subject. The clinical features of the several diseases of the brain have been, and are now, more attentively than ever studied by hospital physicians; the symptoms observed during life are compared with the results of post-mortem examinations; and by simultaneously bringing anatomy, experimental physiology, clinical medicine, and pathology to bear upon this great question, the present doctrine of brain-function eventually became established.

Functions of the Medulla Oblongata.—"We may subdivide the brain into five principal parts, which greatly differ in general configuration, and which, although they are in the most intimate connection with each other, yet are invested with thoroughly different functions. They stand in the relation of higher and lower centers, the lowest being the medulla, and the highest the gray surface of the hemispheres. The functions of these parts will now be considered *seriatim*, beginning with the lower centers.

"1. The *medulla* forms the connecting link between the spinal cord and the brain. It is a small cord, about an inch long, and weighing no more than two drachms; yet it must be looked upon as the most vital part of the whole system, for injury to it proves immediately fatal. The most important function of the medulla is to cause and to regulate the respiratory movements, and the point in which

*Dr. Julius Althaus.

this respiratory center is situated is called the *vital knot.* Death by hanging results generally from injury to this special point in the medulla, through dislocation or fracture of the upper portion of the spine; the criminal therefore dies of asphyxia, or cessation of respiration. The entire brain above the medulla may be removed in an animal, and the latter may yet continue to breathe; but destruction of the medulla asphyxiates it at once. The same organ also regulates the heart's action. It is true that the pulsations of the heart are not, like the respiratory movements, at once arrested by destruction of the medulla, for they may continue for some time after death from hanging. Indeed, the rhythmic beating of the heart is effected by means of small nerve cells which are situated in its muscular substance, and which may retain their energy for some time after death. The influence of the medulla upon the heart is therefore a secondary one, that is, to retard or accelerate its action. The medulla is never at rest as long as life lasts; for respiration and the heart's action continue during sleep as well as in the waking condition in a typical manner.

"The medulla is likewise the center of action for the blood-vessels. These are not always equally distended by the circulating liquid, but may contract and dilate, as is seen in sudden blushing and pallor, under the influence of diverse mental emotions. The insensible perspiration of the skin, which, like respiration, is also going on constantly, is likewise under the influence of the medulla.

"A pointed illustration of these facts is given by the symptoms of the peculiar disorder known as sun-stroke. This affection occurs more particularly in the tropics, but is occasionally observed in hot weather in the temperate zone, in persons who are exposed to the direct rays of the sun, and who have at the same time to undergo exertion. It is therefore chiefly seen in soldiers marching during the heat of the day, or in agricultural laborers who are at work in the fields; yet it has been known to come on at night, in persons sleeping in the pestilential atmosphere of overcrowded and badly ventilated barracks or cabins, and in children shut up in a stifling bedroom after having been exposed to great heat during the day. It would therefore be more appropriate to speak of heat-stroke, for the disorder really consists of a great and sudden rise in the temperature of the blood, which in this state acts as a poison on the medulla. The perspiration of the skin is suddenly arrested, and as the evaporation of sweat on the surface of the body is intended to produce cold, and thus to neutralize the effects

of the external heat, the closure of this safety-valve causes a further rise of temperature, which paralyzes some or most of the centers in the medulla. The worst kind of heat-stroke is that in which the centers for respiration and the heart's action are affected, as fatal asphyxia or syncope is the result. A person who may be walking in the street or working in a field is seen suddenly to drop down as if shot or struck by lightning, and dies in a minute or two. A fatal issue is in such cases so rapid that there is no chance for any treatment to do good, more especially as the means which would be of the first importance, viz., ice and plenty of cold water, are usually not at once at hand.

"The second kind of sun-stroke is owing to paralysis of the center for the blood-vessels in the medulla, whereby apoplexy is caused. In such instances the symptoms are not quite so sudden, and death may often be averted. The illness begins with mental disturbance—there are delusions and hallucinations, followed by mania, and the patient may commit suicide or homicide. This stage of excitement lasts for a short time, and is succeeded by a period of depression. The patient becomes sleepy, insensible, and may die in a state of profound apoplexy. Life is, however, often saved by drenching the body with cold water, and applying ice to the head. The overheated blood is thereby cooled, and the medulla roused from its torpid condition.

"The movements of swallowing, which require for their proper execution a co-ordinated action of the lips, tongue, palate, and gullet, are likewise under the immediate influence of the medulla. The same organ contains a center for the physiognomical play of the muscles of the face, and another for articulate speech, that is, the pronunciation of vowels and consonants in such fashion as to form words. These facts are well illustrated by the symptoms of a peculiar disease which, although it has no doubt always existed, has only recently attracted the attention of the medical world, and which consists in a wasting away of those nerve cells in the medulla which preside over the functions just mentioned. This affection, which has received the euphonious name of 'labio-glosso-pharyngeal paralysis,' commences with apparently insignificant symptoms. It is found that speaking, eating, and swallowing require an effort. The tongue feels heavy; the lips do not move properly; the patient experiences difficulty in pronouncing certain letters, such as *b*, *p*, *o*, and *u*; he cannot whistle or blow out a candle. As time goes on, the tongue becomes more powerless;

more letters of the alphabet are lost; the soft palate does not act properly, and the voice acquires a nasal twang. The vocal cords become paralyzed, the voice is completely lost, and the patient is only able to grunt. He cannot blow his nose, clear his throat, cough, or swallow. In attempting to eat, the tongue fails to form a proper morsel of the food taken, and to push it on to the gullet. The food remains, therefore, between the teeth and the cheeks, and can only be pushed farther on to the throat by the aid of the fingers. It is apt to get into the windpipe and cause choking. On attempting to drink, the liquid returns through the nose. The unfortunate sufferer thus dies a slow death from starvation, the torments of which can only inadequately be relieved by medical aid. On making a post-mortem examination, wasting of certain nerve cells in the medulla is discovered to be the cause of this terrible malady.

"All these different functions of the medulla which we have considered are automatic or mechanical, that is, independent of volition, intelligence, or any other of the higher mental processes; and they may therefore continue where the higher centers in the brain have been either experimentally removed, or disorganized by disease."

Functions of the Pons and Optic Lobes.—"2. The next great division of the brain which we have to consider consists of the *pons*, or bridge, and *optic lobes*, and is the center for still more complicated actions than those over which the medulla presides. The functions of these parts have been chiefly made known by experiments on living animals. A pigeon which is left in possession of these parts, but from which the higher portions of the brain have been removed, is still able to respond to a stimulus, but, if left alone, will show complete indifference and loss of initiative. There is no desire, no impulse to any spontaneous action, and apparently no recollection of any former events. Such an animal will remain, day by day, sitting quietly on its feet, without giving any signs of life, and, unless artificially fed, will ultimately die of starvation, without feeling the pangs of hunger and without suffering in any way. As soon, however, as its repose is disturbed, it will give signs of life. If laid on the back, it will struggle until it has regained its previous position on the feet. If pinched, it will walk away. If thrown into the air, it will flap its wings, and come down to the ground in the ordinary manner. If a light be held to the eyes, the pupils will contract. If ammonia be applied near the nostrils, the animal will draw back with signs of disgust. If a shot be fired close

to it, it will jump up and open its eyes; and if food be put into its mouth, it will swallow it.

"In frogs and fishes the phenomena are almost identical with those observed in pigeons, being only slightly modified by the different media in which the animals live. In the fish, for instance, the contact with the water acts as a constant external stimulus on the mechanism of swimming. A fish from which the higher portions of the brain have been removed, will therefore not sit still, like the pigeon, but will go on swimming until it reaches an impediment to its passage. It follows a headlong and apparently irresistible impulse, yet will show some method, inasmuch as it will avoid obstacles, and turn aside when prevented from going straight on. While a fish in its normal condition will, as may daily be seen in an aquarium, stop on its way, sniff about, pursue a prey, etc., the unbrained fish sails heedlessly along, without ever stopping or taking nourishment, until it dies of exhaustion. In a similar manner an unbrained frog, when thrown into the water, will move on until it reaches *terra firma*, but, as soon as it has found a resting-place, will remain in the same state of death-like repose as the pigeon.

"In the mammalia the results differ somewhat from those obtained in the lower animals. In them the different portions of the brain are so intimately connected, and so dependent upon one another, that removal of the higher parts appears to disorder the entire mechanism, and causes such a degree of exhaustion as to interfere greatly with the independent action of the lower centers. Nevertheless, the functions of these latter are identical with those of the same parts in the lower animals, which we conclude from their homologous structure, and also from observations made in disease of these centers.

"The expression of the affections, such as fear, terror, pleasure, pain, etc., is likewise under the influence of the second division of the brain. Frogs, in which the higher portions of the brain have been destroyed or removed, will still croak when stroked across the back; and croaking in the frog is the expression of satisfaction and comfort. In ourselves, laughing and crying, and other expressions of the affections, are generally quite involuntary, and independent of reflection. It is true, that we may, by an effort of the will, restrain or inhibit such expressions; but this is done by a special exertion of the inhibitory influence of the higher centers, which can only come into play after a long course of training, and which is quite absent in children and uneducated persons."

Functions of the Cerebellum.—"3. The *cerebellum*, or little brain, which is intimately connected with the preceding and following divisions, was formerly believed to be the seat of the reproductive faculty and desire; but this view has recently been shown to be incorrect. Nor has the cerebellum anything to do with reason, volition, or consciousness; for animals which are deprived of the higher centers, yet left in possession of the cerebellum, do not show any spontaneity of desire or action, and will, for instance, die of starvation with the utmost indifference. If, however, the cerebellum be removed, the animal will move about as if it were drunk. It is not paralyzed, and will endeavor to carry out certain movements, but there is an utter want of precision; and even the most desperate efforts do not succeed in steadying the body. The cerebellum is thus shown to be the organ of equilibration of the body; and this conclusion from physiological experiments has been corroborated by observations of disease of the organ in man. It is likewise known that the different portions of the cerebellum have different parts allotted to them in this respect. One part prevents us from falling forward, another from falling sideways and from constantly turning round in a circle, while a third is intended to secure us from falling backward."

Functions of the Central Ganglia.—"4. The *central ganglia*, which constitute the fourth great division of the brain, have the function to render certain complex movements which are intimately connected with sensations, and which are, in the first instance, only excited by volition and consciousness, gradually, as it were, mechanical and automatic. The object of this contrivance is to save time and trouble to the highest portion of the brain, viz., the gray surface of the hemispheres. It is intended that these latter should only be occupied with the most important manifestations of life. The central ganglia may therefore be said to be the confidential servants or private secretaries of the hemispheres, and undertake a good deal of drudgery, in order to leave the gray surface at liberty for the finer and more difficult inds of the work which falls to our lot in life. Thus we have, in childhood and youth, to learn the actions of walking, talking, writing, dressing, dancing, riding on horseback, decent eating and drinking, singing, playing of musical instruments, etc., by countless conscious efforts on the part of the hemispheres; and full attention is necessary in the beginning in order to enable us to carry out such movements in a proper manner. But the older we grow, the

more frequently we have directed our minds to all these forms of activity, the less effort will eventually be necessary on the part of consciousness and volition; and ultimately all such movements will be performed mechanically, and without much, if any, attention to them on the part of the gray surface of the brain. A man who is in the habit of writing much never thinks of the way in which he forms his letters on the paper, over which his pen seems to fly quite mechanically. The same holds good for the various kinds of needlework, embroidery, playing on the piano, the violin, etc. If, each time we do anything of that sort, a conscious effort were necessary for all the different parts of which the action is composed, the time at our disposal would not suffice for the hundredth part of the work which we actually get through in life; and some forms of activity, such as finished piano and violin playing, would be utterly impossible.

"A key is thus furnished for the comprehension of many singular occurrences which would otherwise be quite inexplicable. A pianist, for instance, finds himself playing one of Rubinstein's sonatas by heart, and is perhaps thinking all the time of his coming trip to Switzerland, or something else which may happen to engage his attention; that is, the central ganglia play the sonata, while the hemispheres are busy elsewhere. A very worthy country parson told me some time ago that, when he reads prayers at church, he does so quite as an automaton, for his mind keeps wandering in a totally different direction. A man who knows London well may walk from his house through a maze of streets with the greatest precision to his club, where he arrives without having given the slightest attention either to the act of walking or to the direction he took, but having been quite in another world of thoughts all the time he was on his way.

"Somnambulism and other automatic conditions, which are observed in certain states of derangement of the nervous system, may be similarly explained. The lower centers are habitually under the absolute control of the highest, that is, the hemispheres; yet this balance of power may be temporarily disturbed by illness or exhaustion of the gray surface, and the central ganglia may then begin to act in their own fashion. What may take place under such circumstances may be aptly compared to certain occurrences which are not uncommon when the family is out of town, and the servants are left in charge of the house. Supposing the hemispheres to have lost their control over the lower centers, elaborate actions may take place which may have all the appearance of delib-

erate intention, and yet for which the person who commits them can no more be held responsible than the absent master of the house for the misdoings of his servants. The somnambulist who falls from the roof of a house and is killed is no more a suicide than a man who in the state of epileptic vertigo commits robbery, arson, or murder, can be called a truly responsible criminal. The legal mind has not yet been able to grasp the full significance of these facts, as shown by convictions to penal servitude of persons who should have been sent to hospitals or asylums."

Functions of the Cerebrum.—"5. The highest development of brain-matter is found in the *hemispheres, convolutions,* or *gray surface of the brain,* which is the material base of all mental and moral activity. This portion of the brain * * * * * is not a single organ, as was formerly supposed, but consists of a number of thoroughly differentiated organs, each one of which possesses certain functions, yet is in the closest possible connection with all the others. To define all these various organs with accuracy, to determine their intimate structure as well as their individual energy, and to trace the physiological and pathological alterations which they undergo during the natural processes of development, maturity, and decay, and in diseases to which they are subject, is the greatest problem for the anatomy and physiology of the twentieth century; and when this problem is solved, a complete revolution in psychology must be the result. At present, however, we are only on the threshold of this inquiry, which is perhaps the most difficult and complicated of any which may present themselves to the human mind.

"I cannot attempt, in the limits of the present paper, to enter at all fully into the labyrinth of these convolutions, but must be satisfied with a rapid survey of what is best known with regard to the functions of some of them. One of the most suggestive results of recent researches has been to show that the faculty of intelligent language, as distinguished from simply articulate speech, is situated in that portion of the hemispheres which is called the third left frontal convolution, and its immediate neighborhood. We have already seen that the pronunciation of letters and words is effected in the lowest portion of the brain, viz., the medulla; but this and all the other inferior organs concerned in speaking form only as it were the instrument, on which that small portion of the brain's surface which I have just named is habitually playing. Lower centers are able to hear spoken words, and to see written words; but the intelligent appreciation of the connection which exists between

words and ideas, and the faculty of expressing thoughts in sentences—that is, what the Greeks called *logos*—only resides in the third left frontal convolution. This discovery was foreshadowed by Gall, but actually made by Broco, who likewise found that the left hemisphere is altogether more important for intellectual manifestations than the right, and is chiefly trained for talking as well as most of the finer kinds of work which we have to perform in daily life. This appears to be owing to the following circumstances: The left hemisphere is originally heavier than the right; the convolutions are more abundantly developed in the left; and finally, the left is more abundantly provided with blood, on account of the larger caliber of the blood-vessels which supply it. Most people therefore train chiefly the left hemisphere for talking, writing, etc.; they are left-brained as they are right-handed. A preponderance of the right over the left hemisphere, on the other hand, seems, according to the most recent researches, to be characteristic of certain forms of insanity.

"Physiological experiments on animals point to the convolution I have just named as being concerned in language; for when electricity is applied to the part in the living monkey or rabbit, the animal opens its mouth, and alternately protrudes and retracts the tongue. But far more convincing proofs have been furnished by numerous cases of disease in which there was loss of language during life, and where after death a lesion limited to the part just named was discovered.

"A boy, aged five, who was a great chatterbox, fell out of the window and injured the left frontal bone, which was found depressed. There was no paralysis, but the boy had entirely lost his language. The wound healed in twenty-five days; but the child, although intelligent, remained dumb. A year afterward he was accidentally drowned, and at the autopsy it was found that the third left frontal convolution had been destroyed by the injury he had received.

"A man fell with his horse, but got up, took hold of the reins, and was going to jump into the saddle, when a doctor who happened to accompany him expressed the wish to make an examination. It was then found that he could not speak, but had to make himself understood by pantomime. A small wound in the left side of the forehead was found, with depression of bone; but there was no paralysis. Inflammation set in, the patient died, and at the post-mortem examination it was found that a fragment of bone had penetrated into the third left frontal convolution, which had become softened.

"Talking, writing, drawing, etc., are habitually done by the left hemisphere alone, while both hemispheres have to be trained for musical performances. Pianists educate them both equally, while violinists and violoncello-players have to train them dissimilarly; and this is probably the reason why it requires more practice, and is more difficult, to play well on string-instruments than on the piano.

"A man who has by disease or injury lost the faculty of talking, is generally also unable to write; and it is only in exceptional cases that one of these functions persists while the other is in abeyance. Cases of this latter kind show, however, that there are really two separate centers for the two faculties which are lying very close together, and therefore generally suffer at the same time. If the disease affecting them be still more extensive, the faculty of intelligent pantomime or gesticulation is likewise abolished. Persons who have entirely lost their language may still be able to play chess, backgammon, and whist; and they have been observed to cheat at cards with some ingenuity; they may also be sharp in business matters,—facts tending to show that speech and intellect do not run in identical grooves.

"Those portions of the hemispheres which correspond to the pareital region or crown of the head, and which are called the *pareital lobes*, constitute the true motor region of the brain's surface, and, being in intimate connection with another portion which is the material base of the intellect and mind, have been called *psycho-motor centers*, in order to distinguish them from the lower motor centers in the medulla, the central ganglia, etc. The special functions of these psycho-motor centers have been studied by the application of electricity, by destroying them in the living animal, and also by observation of certain symptoms at the bedside; and it has been shown that each one singly serves some definite purpose, as, for instance, clenching the fist, swimming, grasping something, raising the hand to the mouth, etc. Destruction of these centers causes paralysis of such movements, while irritation of them leads to a peculiar form of epilepsy, in which the convulsions affect only one (the opposite) side of the body, and where there is generally no loss of consciousness.

"The next great division of the brain's surface is that which corresponds to the temporal region of the skull. These *temporal* lobes of the hemispheres are intended to act as centers for sensory perceptions. This is likewise shown by galvanizing them in the living animal, and by localized destruction of the same. One portion of the

temporal lobe is the center of the sense of hearing. If it be destroyed, deafness on the opposite side is the result; on the other hand, if it be electrified, the animal is seen to prick up its ears and to assume the attitude of listening, just as it does when a sudden noise is made close to its ear. In those animals whose habits of life render their safety dependent upon the keenness of their sense of hearing, as, for instance, the wild rabbit and the jackal, galvanization of that part causes not only pricking of ears and listening, but also a quick jump to the side, as if to escape from some danger which would be announced by a loud or unusual noise.

"The center for the sense of smell is situated close by. If it be electrified, the animal begins to sniff, as if it smelt something strong, just as it does when odoriferous substances are placed to its nose. Destruction of this center causes loss of smell. It is particularly developed in animals which are endowed with a keen sense of smell, such as dogs, cats, and rabbits. A center for the perception of taste is in its immediate neighborhood. Other portions of the temporal lobes are intended for the sense of touch, and there is also a visual center, destruction of which causes blindness of the opposite side. All these centers are symmetrically arranged on both sides, the left in the brain serving for the right side of the body, and *vice versa.*

"A third portion of the hemispheres which we have to consider are the *posterior* or *occipital* lobes, which correspond to the back of the head. Their structure differs greatly from that of the parts more in front, and they receive their blood supply from quite a different set of blood-vessels. Electricity has apparently no influence upon them, and destruction of their substance causes neither paralysis nor loss of sensation. Animals from which these lobes have been removed continue to see, hear, touch, taste, smell, and move about just as usual. They generally, however, refuse to eat, and succumb rapidly. We are inclined to look upon these lobes as specially connected with the digestive tract, more especially the stomach and liver, and also with the reproductive organs; yet the symptoms of disease of these lobes are contradictory and perplexing, and our knowledge concerning them is as yet in its infancy.

"The last and most important portion of the hemispheres consists of the *anterior* or *frontal* lobes, which correspond to the forehead. They are the actual seat of the intellect. Injury or disease of these lobes does not cause any impairment of motion or sensation; and large

portions of brain-matter have occasionally been lost through wounds in these parts without any very striking symptoms, such as paralysis, etc., following, more especially if the lesion was confined to one side. Patients have now and then recovered from the most fearful injuries to the anterior lobes, and yet been able to go about and to attend to the ordinary routine of certain occupations; but it has always been shown, on close examination, that there had been a profound change in the character and behavior of such persons, and that their temper and their mental and moral faculties had become deteriorated. In a very marked case of this kind, which occurred some years ago in a previously steady and clever workman, there was, after recovery from the injury, such a change in the mind of the man that his employers had to discharge him. The balance between his intellectual faculties and his animal propensities had evidently been destroyed. He had become capricious and vacillating, fitful, impatient, obstinate, and, as far as intellectual capacity was concerned, appeared to be a child, which, however, had the animal passions of a strong man. In consonance with such cases is Ferrier's experience with monkeys in whom he had destroyed these lobes. The animals did not appear to have lost the power of motion or sensation, but there was an alteration in their character. While previously to the operation they were actively interested in their surroundings, and pried into everything which came within their sphere, they had after it become dull and apathetic, readily dozed off to sleep, or wandered to and fro in a listless manner; so that it was evident that they had lost the faculty of attentive and intelligent observation.

"The anterior lobes have therefore to be looked upon as the organic base of the highest intellectual and moral faculties. The principal part of the work done in life consists of certain movements or actions, which are the more or less immediate consequence of sensations and desires which we experience; but apart from the power of performing such actions, we possess the faculty of restraining or inhibiting them in spite of being urged to their performance by sensations or desires. This inhibitory action is again most intimately connected with the power of concentrating attention, without which none of the higher intellectual operations are possible. The anterior lobes are therefore inhibitory centers, intended for the highest kind of mental work and moral control. They are small in idiots and the lower animals, larger in monkeys, largest in man; and their pecul-

iarly large and abundant development is found to coincide with the highest development of intellectual power.

"It is probable that a special evolution of certain parts of these lobes will be found to coincide with the presence of certain special aptitudes and talents in individuals; but of this nothing definite is known, and there is in this direction an immense field still open for patient and intelligent inquiry."

The Functions of the Spinal Cord.—The spinal cord contains both gray and white matter, the gray matter consisting of nerve-cells and the white matter of nerve fibres. The function of the nerve-cells seems to be to have charge of certain automatic movements which are performed independent of the will, or involuntarily. These movements are generally termed reflex, since they are supposed to originate in external impressions which cause an impulse to be carried to the spinal cord by a sensory nerve, the impulse being reflected to the muscles by a motor nerve. This is well seen in a frog which has been decapitated. If a little sulphuric or acetic acid be applied to the inner portion of the thigh of a frog which has just been deprived of its head, it will immediately put up the other foot to remove the irritating substance. If the acid is applied to the belly instead, both feet will be raised, and vigorous movements will be made to remove it. If placed upon its feet, such a frog will remain perfectly quiet if wholly undisturbed; but so soon as any sort of irritation is applied, as tickling with a stick, pricking, or even jarring of the object on which it rests, it will leap forward as though alive. These movements are said to be reflex because they are supposed to originate in the manner described, from the gray matter of the cord. There are eminent physiologists who maintain that experiments of this kind prove that the cord as well as the brain is the seat of mind, even going so far as to assert that mind exists wherever gray matter is found, being a property of nerve-cells.

The spinal cord also acts as a conductor of sensations to the brain, and of volitions from it. The nerves of general sensibility convey to the spinal cord impressions received in various parts of the body, when they are carried up to the brain by means of the gray matter of the cord. The brain then wills the performance of an act, and the force necessary to excite the muscles to contract is sent down the spinal cord and thence out through some of its nerve branches to the part from whence the impression came. For instance, if a pin is thrust into the finger, the sen-

sation which we call pain is transmitted by means of a sensory nerve to the cord, which passes it up to the brain, where the sensation is really felt, the brain itself being not sensitive, since it may be cut and torn without pain, though it appreciates injuries done to other parts of the body. The cord is thus seen to be both a conductor of nerve force and a nerve center or force generator.

The reflex action of the cord is often seen in human beings in cases of paralysis in which there is loss of power to control the lower extremities. We have frequently met with such patients, in whom the limbs could be made to twitch with considerable force by titillation of the soles of the feet, though the muscles would not act in obedience to the will on account of some injury in the nerve centers having charge of that part of the body or in the nervous communication between the two.

Functions of the Spinal Nerves.—The thirty-one pairs of nerves which originate in the spinal cord are each double. This might be easily surmised from the fact already stated, that each nerve has two roots, one of which arises from the posterior portion of the cord, the other from the anterior portion. It has been found, by experiments upon animals, that the fibres which come from these two roots differ from each other in function, the anterior roots being nerves of motion, and conveying nerve force from the cord to the muscles, and those which are connected with the posterior root conveying impressions from various portions of the body to the cord. Hence the anterior root and fibres arising from it are termed motor, the posterior root and its fibres being called sensory.

A curious fact discovered by physiologists is that both the motor and sensory fibres, which, as we have seen, communicate with the brain through the cord, cross over to the opposite side from that on which they enter the cord before passing into the brain. The sensory fibres pass over or decussate soon after entering the cord, while the motor filaments cross over in the medulla oblongata, or at the base of the brain. The consequence of this is that if an injury happens to these nerve fibres in the brain or the cells in which they terminate or originate, the injury will be manifested upon the opposite side of the body. Thus, paralysis of one side of the body may be taken as evidence that the opposite side of the brain has been injured.

Functions of the Cranial Nerves.—The functions of the nine cranial nerves are far less simple than those of the spinal nerves just described. In some instances a nerve has both motor and sensory functions, but in several others a nerve has but a single function. Several

of the cranial sensory nerves, instead of possessing general sensibility, have peculiar sensory properties, from which they are termed nerves of special sense. The *optic*, or nerve of sight, *auditory*, or nerve of hearing, the *olfactory*, or nerve of smell, and the *gustatory*, or nerve of taste, are those which possess special sensory properties, and these possess little or no general sensibility.

The fifth nerve should be specially noticed as the great sensory nerve of the face, since it is disease of this nerve which is the occasion of so much suffering in *tic douloureux*, or facial neuralgia. A branch of this nerve supplies the teeth, and hence it is that decayed or diseased teeth are so frequent a cause of facial neuralgia.

Functions of the Sympathetic System.—The name of this system of nerves very well indicates its general character. Besides having charge of the nutrition of the body, its vegetative or organic functions, it connects or associates together the different parts of the system, so that when one member suffers, the others suffer with it. A good illustration of the action of this system is seen in a simple experiment performed by Dr. Brown-Sequard. He observed that when he placed one foot in cold water, the other became warmer. In one instance the temperature of the foot not immersed rose seven degrees. The reason of this is that nature makes an effort to resist the effects of the cold applied to one foot, by increasing the supply of heat; and through the sympathy of the other foot, its heat is increased also.

The very common phenomena of "taking cold," and numerous other instances of sympathy of one part with another, are due to the action of the sympathetic nerves.

The Mind.—Whatever may be the correct doctrine respecting the nature of the human soul, about which science can really say very little, it seems very clear from what has been proven respecting the nature of the brain and its processes, that mind is nothing more nor less than brain action. It is everywhere granted that the brain is at least the organ of the mind. It is certainly relevant to inquire, then, Is not the relation between the mind-organ and the mind analogous to the relation known to exist between the organ of digestion and digestion? Digestion is a process, thought is a process. Digestion is the result of the action of the digestive organs; there is abundant reason to believe that thought or mind is the result of brain action. This view need not interfere with any theological views concerning the nature of the soul, since it

is evident that whatever the soul is, it is something more than mind; it must be greater than mind, since mind is only a result, from whatever standpoint we look at it. Whatever there may be behind which we do not understand, and there is doubtless a great deal, mind is still the same, but a result; and it may as well be considered as the result of brain action as of the action of any other cause. If we deny this regarding man, we must do the same respecting the brute, since he also has a mind, and is capable of thinking, willing, and reasoning to a certain degree. Perhaps we cannot do better than to quote the following paragraph from one of the foremost thinkers of the age, and one of the most distinguished writers on this subject, Dr. Henry Maudsley, of London :—

"It must be distinctly laid down that mental action is as surely dependent on the nervous structure as the function of the liver confessedly is on the hepatic structure; that is the fundamental principle upon which the fabric of a mental science must rest. The countless thousands of nerve cells which form so great a part of the delicate structure of the brain, are deemed to be the centers of its functional activity; we know right well from experiment that the ganglionic nerve cells scattered through the tissues of organs, as, for example, through the walls of the intestines, or the structure of the heart, are centers of nerve force ministering to their organic action; and we may fairly infer that the ganglionic cells of the brain which are not similarly amenable to observation and experiment, have a like function. Certainly they are not inexhaustible centers of self-generating force; they give out no more than what they have in one way or another taken in; they receive material from the blood which they assimilate, or make of the same kind with themselves; a correlative metamorphosis of force necessarily accompanying this upward transformation of matter, and the nerve cell thus becoming, so long as its equilibrium is preserved, a center of statical power of the highest vital quality. The maintenance of the equilibrium of nervous element is the condition of latent thought—it is mind statical; the manifestation of thought implies the change or destruction of nervous element. The nerve cell of the brain, it might in fact be said, represents statical thought, while thought represents dynamical nerve cell, or, more properly speaking, the energy of nerve cell."

Almost any amount of testimony might be added on this point, but this will suffice. It is readily granted that there are some difficulties, even with this view of the nature of mind; but it is claimed

that the difficulties with this view are much less than with any other, and that they are not insurmountable. The view deserves attention, at least; since if it be true, it is destined to overturn many of the old philosophies in psychology. Indeed, it may almost be said that the old philosophies are already abandoned by the majority of the clearest thinkers, on account of the great numbers of difficulties which attended them.

The Mechanism of Thought.—Explained in accordance with the scientific theory of mind, the mechanism of thought loses much of its complexity, as we may be able to see. According to this view, thought really originates in the external world. The eye, ear, organs of touch, smell, and taste, and other sense organs, receive impressions from the external world, each carrying to the brain the particular kind of impression which it is fitted to convey. The eye conveys impressions of light, the ear of sound, etc. These impressions are received through the medium of the nerves by certain groups of cells lying at the base of the brain which are designed for this purpose. One group receives impressions of light, and of all the sensations which can be received through the eye. It can receive these kinds of impressions, and no others. The same may be said with respect to each of the other senses. The special organs, or ganglia, which receive these impressions, transmit them through connecting branches to the intellectual part of the brain in the cerebrum, where they are recognized as light, sound, odor, etc., and this is thought. In this way, ideas respecting the size, form, color, and other properties of objects, are formed. If the ganglia at the base of the brain convey to the cerebrum the impressions which they are in the habit of doing, without being excited to do so by the external agents upon which they are dependent, the result is the same. If action of the ganglia which presides over the organ of sight is excited and the cerebrum informed of the fact, the individual will receive the perception of light even if no light is really seen. Action of this sort may be excited in a variety of ways, as by mechanical irritation or by the use of electricity. Every one who has received a severe blow upon the head, as by a fall upon the ice, is aware of the fact that concussion of the head will cause a person to see flashes of light. A story is told of a man who in an English court testified to having seen a man who assaulted him in the dark by the light produced by a blow on the head which he received from his assailant. It is not stated whether the testimony was received or not.

Of course it could not be true, since light thus produced is not real, having no existence except in the brain. We have many times produced the same phenomena by the application of a current of electricity to the head. Distinct flashes are seen, though the eyes are closed. From this it appears that the impression we call light is in the brain due to action of certain nerve cells. The same experiment may be made with all the other organs with a like result. Ordinarily, seeing is the reception of light-waves through the medium of the eye, which is an organ specially constructed to receive them, by which means the optic nerve is made to convey an impression of a certain sort to the cells in the brain set apart for the reception of such impressions, which are thereby induced to act, which action is recognized by the cerebrum, the seat of the intellect, as light. If the optic cells are made to act in any other way the result is the same, as we have seen. It is very evident, then, that so far as the external world is concerned, all knowledge respecting it comes to the brain through the organs of sense, the only avenues of communication between the brain and the outer world. A careful analysis of our stock of knowledge will show that it all relates to things of which we have gained information by means of our senses; that is, all our knowledge is made up of, or derived from, data collected for us by the eye, ear, touch, and other sense organs. If this is not clearly seen at once, it will be by the supposition of a case. Let us imagine a person born into the world without a single one of the seven senses. It is inconceivable that such a person could have a single thought. The life possessed would be but a vegetative one. The brain would necessarily be an utter blank, since it would be without the most simple materials for thought; there would be no means by which the intellectual machinery could be set in motion.

We have not space to elaborate this subject further, and here leave it for the consideration of the reader, hoping that those who are prepared to appreciate the questions at issue will continue their investigation of the nature of mind and the relation of mental activity to the brain and nerves.

The Will.—That power of the mind by which the voluntary acts of the body are determined or controlled is termed the will. This is undoubtedly the highest function of the brain, since all other of both the bodily and mental functions are in some degree subject to it, either directly or indirectly. While this is probably the most obscure of all

the questions connected with the physiology of the brain, there are some very interesting facts known concerning it which are well worthy of consideration.

First, as to the nature of the will. This has been the subject of lively discussion among physiologists and metaphysicians for centuries. We hear much about *free* will; yet when we come to study the manifestations of volition we find that they are far from possessing that degree of freedom which the generally accepted doctrines on the subject would lead us to suppose. If we carefully analyze an act of volition, we shall find that desire is the prompting impulse in most if not all cases. When we act, it is because something which we regard as valuable to ourselves or some other being is to be gained by so doing; in other words, we act because it is desirable to do so, or seems to us to be desirable. We always do what at the moment seems to be best, whatever its ultimate consequences may be, and irrespective of our knowledge of the consequences. When we refrain from action, it is because we *desire* to do so. Thus will may be manifested in two ways, positively and negatively, in acting and in refraining from action; but in both instances the prompting of will is desire. This fact seems so clear that we apprehend no one will dispute or disagree with it who will stop to reason candidly on the subject.

If we examine into the nature and origin of desire, we shall find that it grows out of a complex combination of circumstances and influences; first of which may be mentioned, inheritance. Our mental and physical constitution is largely the result of the habits and education of our parents and ancestors for many generations back, together with special circumstances governing our early development. As Dr. Oliver Wendell Holmes has very well said, "Each of us is only the footing up of a double column of figures that goes back to the first pair. Every unit tells, and some of them are *plus*, and some *minus*." The proofs of this are too numerous to need citation here.

Again, our desires are in a great degree the result of our education. Our tastes change with changes in our circumstances. They are modified by age, and by our associations and social surroundings. Our desires are influenced by those of our friends, by the books we read, by the food we eat, by the condition of our bodily health, and by a great variety of circumstances. It is obvious, then, that as the will is excited to action by desire it is far from being wholly *free*, since it is indirectly so dependent on other influences and circumstances.

We are well aware, also, that the will is greatly modified by disease. A person who in health is active, energetic, positive in all his movements, becomes while suffering from some indisposition, the very reverse. A fit of sickness, a pecuniary loss, or other misfortune, will not infrequently change a person's disposition and the character of his will manifestations, for life.

A careful study of the relation of the will to the body will show that its domination is far less complete than usually supposed. It has no power over the functions of organic life, as of the heart and blood-vessels, the stomach, intestines, and other vital organs, and it is fortunate for us that it has not, as the uncertain action of the will—it being so readily affected by a great variety of causes—would be fatal to the healthful and harmonious action of the vital machinery. Even the power of control of the so-called voluntary movements is only acquired by degrees and after a protracted effort. In this respect, man is inferior to some lower animals. The little child learns to walk by painful and laborious efforts. At first it cannot control the muscles necessary to effect locomotion. It can readily understand what movements must be made, long before it can acquire the power to make them. The beginner in piano-playing fully appreciates the difference between knowing how to do, and doing. The will calls upon certain muscles to act, but they will not until they have been trained to do so. This fact is further seen in the great difficulty of making separately movements which have by habit been associated, as for example, closing one eye while keeping the other open; or moving one hand back and forth in a horizontal plane while the other is being moved in a vertical plane, both palms looking downward. It is, indeed, sometimes impossible for us to control our mental operations by the will. We cannot think of what we wish to. We cannot on all occasions concentrate our minds upon the subjects of which we desire to think. The mind will wander into other fields; other and widely different subjects of thought will occupy its attention in spite of the most vigorous efforts of the will to the contrary. We cannot command the brain to stop thinking. It will not obey if so commanded. We cannot even compel it to stop thinking upon any special subject which may be occupying it except by displacing it by some other idea, which may be in turn again displaced by the original thought before we are aware of it.

Without further argument it must be evident that the will is by no means wholly free, but that it is, in a very large degree at least, the re-

sult of the operation upon us of the various external influences with which we are surrounded.

Physiologists have never been able to locate the will in any particular organ of the brain. It is probable that it exists in immediate connection with each of the various cerebral centers; in other words, that each group of cells which receives nerve fibres from the outside of the body and sends back motor fibres possesses its own volition, the will being the sum total of action of all these volitionary centers.

Memory.—Memory is that faculty or property of the brain by means of which we are enabled to accumulate knowledge. To say that all of the problems involved in a complete explanation of memory may be easily solved, would be claiming too much. This much seems pretty certain, however, viz., that memory is due to the fixing of impressions in the structure of the brain. This view harmonizes perfectly with all the known facts relating to this most valuable function of the mind. Every impression received, occasions an action of certain parts of the brain. As changes of substance are constantly taking place in the brain, it is but natural to suppose that cells which are acting will be modified in accordance with the particular manner in which they are acting, their structure being thus modified by their action. If this were the case it would follow that the longer the action were continued the more intense would be the impression made upon the structure of the cells acting, and the more lasting. This is exactly what does happen. The longer an object is viewed, the longer the memory of it remains. The things and places which are often seen and become very familiar to us are seldom forgotten.

Again, if this theory is correct it would follow that the larger the number of cells brought into action by an impression as associated with it, the more intense and lasting would be the impression. This, too, is undoubtedly true. We much better recollect things that we both see and hear, than those which we simply see or hear. Objects that we not only see and hear but are also able to touch, taste, smell, and otherwise investigate, we retain in mind the most accurately and the longest. In fact, the great secret of a good memory is concentrated attention and association of many senses and faculties in observation. By this means we gain the advantage of the memory of several different organs or cell groups by which to recall the object or fact which we wish to remember.

This theory also explains the phenomena of habit. By frequent ac-

tion in a certain way the structure of the nerve cells which command the action becomes so modified that they act more readily in that particular way than in any other. This fact, if it be true, and there seems hardly a chance to doubt it, is certainly very suggestive of the importance of cultivating right habits of thought, speech, and action, since the task of remodeling a deformed and distorted brain is an exceedingly difficult one.

Blushing.—The sudden reddening of the cheeks known as blushing, is due to the influence of certain emotions upon the *vaso-motor* center, that is, the part of the brain which controls the blood-vessels of the body. In some persons, blushing is wholly confined to the cheeks, while in others it extends to the forehead, and in still others to the neck and shoulders. Through the influence of mental emotions the walls of the blood-vessels become relaxed, causing an unusual afflux of blood to the part, which imparts the characteristic redness. An experiment sometimes performed by physiologists upon white rabbits illustrates the phenomena of blushing and explains its mechanism. In the white rabbit the skin is white, and so transparent that changes in the blood-vessels can be as readily noted as in human beings. Placing the animal under the influence of ether, the experimenter divides the nerve which controls the circulation in the ear. The result is that the ear immediately becomes flushed; in fact, it blushes. If the nerve is prevented from uniting, by removal of a portion of it, the flushing will continue, and, in consequence, in the course of a few months it will be found that the ear affected by the operation has grown to be appreciably larger than the other, in consequence of its larger supply of blood.

Pain and its Uses.—Pain is simply a modification of general sensibility. It arises from excessive irritation or stimulation of the nerves. Thus, the same irritation which in moderate degree, or when of short continuance, is agreeable, giving pleasure, when rendered more intense, or even if long continued, becomes exceedingly painful. For example, the sense of contact of bodies with the skin is not unpleasant, and is often very agreeable; but when the contact is made in a peculiar manner, as in titillation, it may become painfully unpleasant. Light is pleasant and grateful to the eye in a moderate degree, but becomes very painful and unbearable when we attempt to look at the sun.

Pain is useful as a warning of impending evil. It puts us on our guard by informing us that the tissues are in danger of being injured in some way. Although unpleasant to bear, and often an unwelcome vis-

itant, pain is a guardian, a faithful sentinel. If it were not for the warnings and admonitions we receive from this source, we would speedily subject the delicate organism to such violence as to impair its functions, if not entirely destroy its utility. This fact is well seen by the accidents to which persons are exposed who are in any way deprived of this means of warning. For instance, a person who had through disease lost the sense of feeling in his lower extremities, in taking a foot bath put his feet into water so hot that the feet were badly burned, being actually parboiled. A gentleman of our acquaintance who had lost the sense of feeling in one arm by an accident in which the sensory nerves of the arm were divided, while at work on a cold day unconsciously froze the fingers of the affected hand so badly that death of the tissues took place and considerable portions were lost. Other similar instances might be cited. The warnings of pain should always be heeded. Nature makes no unnecessary complaints. While it is not wise for a person to be on the lookout for pains, magnifying every uncomfortable sensation, it is important that the timely admonitions of beginning disease should be carefully heeded. Neglect of this often sacrifices useful lives which might easily be saved with timely attention. Pain, then, should be looked upon as a beneficent provision of nature rather than as an enemy.

The great physiologist, Magendie, makes the following interesting remarks concerning the nature of pain:—

"Though it may appear like sophistry to say that pain is the shadow of pleasure, yet it is certain that those who have exhausted the ordinary sources of pleasure have recourse to causes of pain, and gratify them by their effects. Do we not see in all large cities that men who are debauched and depraved find agreeable sensations where others experience only intolerable pain?"

We have seen old topers whose sensibilities had become so depraved and benumbed that the strongest liquors failed to excite them, fill a wineglass with peppersauce, and quaff the liquid fire as though it were a glass of milk or the mildest claret.

Numerous experiments and observations show that the capacity for pain increases with the fineness of the organization. It is pretty clearly settled that lower animals suffer much less from the same injury than man. Indeed, it is maintained by some that in the lowest orders, as in worms and reptiles, there is little if any sensibility to pain, the contortions arising from injury, being really reflex in character. It is notice-

able that savages, as a rule, are less sensitive to pain than civilized persons.

Sleep.—Sleep is a physiological condition in which there is cessation of activity of the upper lobes of the brain. When a person goes to sleep, the blood leaves the brain, the membranes becoming pale and the activity of the nerve cells ceasing in consequence. Upon waking, the blood returns again very quickly. This fact has been observed not only in animals, but in human beings in whom large portions of the skull have been removed by accident. During perfectly sound sleep there is no action of the thinking cells of the brain. There may or may not be some degree of activity of the central ganglia, the sensational centers, so-called, at the base of the brain, but there will be no degree of activity in the cerebrum.

Dreams never occur in perfectly sound sleep. They are an indication that there is not complete cessation of activity in the cerebrum. The will being dormant, the various faculties act in an irregular, disorderly manner, giving rise to a great variety of absurd, grotesque, inconsistent mental pictures. It has been remarked that dreams are the best index to a person's character, since they are really but the echoes of our waking thoughts. The superstitious confidence which many persons put in dreams is in the highest degree unphilosophical, and has not a shadow of evidence in its favor. Late eating and deficient physical exercise are the most common causes of bad dreams.

Somnambulism.—The habit of walking about while asleep is one of the most curious of all the phenomena of nervous action. The somnambulistic state is simply an exaggeration of the state of dream. It is a condition in which the intellectual faculties are dormant, while many parts of the brain seem to be even more active than usual. While in this curious state, persons will accomplish feats which would be impossible for them while awake.

Many remarkable instances of somnambulism are recorded. For example, a story is told of one Cortelli, who "was found one night asleep in the act of translating from a dictionary. When his candle was extinguished, he arose and went to seek another light. When any one conversed with him on any subject on which his mind was bent at the time, he gave rational answers, but he seemed to hear nothing that was said to him or near him on other subjects. His eyes also seemed to be only sensible to those objects about which he was immediately engaged, and were quite fixed; so much so, that in reading he turned the whole head from side to side instead of the eyes."

Another very remarkable case is related by the Archbishop of Bordeaux in the "Encyclopedia Methodique." "It was concerning a young priest at the Catholic seminary, who used to rise in his sleep and write sermons. Having written a page, he would read it aloud and make corrections. 'I have seen,' says the Archbishop, 'the beginning of one of his sermons which he had written when asleep; it was well composed.' . . . . . He continued to write, although a card was held between his eyes and the paper. Did the history stop here, we should have a well-authenticated case of vision without the aid of the eyes. But the collateral circumstances show that this writing was accomplished, not by sight, but by a most accurate mental representation of the object to be attained. For after he had written a page requiring correction, a piece of blank paper of the exact size was substituted for his own manuscript, and on that he made the corrections in the precise situation which they would have occupied on the original page. A very astonishing part of this report is that which relates to his writing music in this sleeping state, which it is said he did with perfect precision. He asked for certain things, and saw and heard such things, but *only* such things, as bore directly upon the subject of his thoughts."

There seems to be a very close relation between the somnambulistic and the mesmeric states. In both there is voluntary action, though the will does not seem to be fully dominant, since movements appear to be in a considerable degree automatic.

Mesmerism.—The secret of mesmerism appears to be in getting the will of the subject inactive, and then putting his sensational centers in operation through the medium of the senses. We cannot imagine that a person could be mesmerized who could neither hear, see, nor feel. From a somewhat careful study of the nature and phenomena of mesmerism we are convinced that at least the greater share of the manifestations, if not the whole, can be explained in this way. At least, we have never seen manifestations which could not be thus explained, without the supposition of any occult force. When a person is to be mesmerized, he is placed under conditions the best calculated to make the will dormant. There must be silence. The subject is usually told to direct his eyes upward, either looking at his hand or at some small, indifferent object which presents few details to furnish fund for thought. After a certain length of time, longer or shorter, according to the individual, in some persons the mind will become va-

cant of thought, the will inactive. The mental organs are then in a condition exactly analogous to that of a scale beam evenly balanced. It is ready to act just according as the impression shall be made, and so nicely adjusted is the balance that only a very slight impression is necessary to turn the scale. The operator then closes the eyes of the subject or tells him to do so, perhaps placing his fingers upon his eyes for a moment. Then he will say to him in a very positive manner, "You cannot open your eyes." The operator does not ask the subject *if* he can open his eyes, but assures him that he cannot. If he finds that the eyes are not opened, he then feels quite sure that his subject is in a condition to be influenced. Then when he tells him to open his eyes, they are opened. He wishes him to appear to be engaged in fishing. He puts into his hands something slightly resembling a fishing-rod, it may be a ruler or a cane. Then he puts into his mind the desired idea by telling him that the object he holds is a fishing-rod. He offers him something and calls it a line, pretends to find the hook and to put a worm upon it, then points in an appropriate direction and says, "There are the fish, see them! throw in your line and catch one." Thus the mind of the subject is influenced by what is said and done to him, what he sees, hears, feels, and otherwise appreciates through his senses. All persons cannot be influenced in this way, simply because their positive mental organization will not allow the mind to become vacant and the will dormant. Persons who are easily mesmerized are those who are naturally easily influenced, whose imaginations are easily excited. A condition very similar to the mesmeric state can be induced in animals as well as in human beings.

The most popular and successful mesmerist at present exhibiting in this country said to us a few months since in a conversation on the subject of mesmerism, in answer to the question whether the subject was not affected wholly through the medium of the senses, "Yes, chiefly so." He endeavored to maintain that there was some degree of direct action of mind upon mind, but was utterly unable to produce an instance in which this was done, even when full credit was given to his own testimony. There is evidence for believing that the cases which seem to illustrate this power of mind are cases of fraud.

Animal Magnetism.—So much has been said upon this subject of late years that we cannot refrain from offering a word upon it, especially as there exist such wide-spread errors concerning it.

The doctrine of an occult force by which one person may operate

upon another, or by which one mind may affect another otherwise than through the medium of the senses, seems to have originated in Paris, in the latter part of the last century, with a pretender whose claims were investigated by a committee appointed for the purpose by the French Academy. Benjamin Franklin, who then resided in Paris, was a member of the committee. After a careful and thorough examination of the claims of the pretender, they were pronounced to be utterly unfounded, it being decided that the phenomena apparently due to the operation of some unseen force, were wholly attributable to the imagination of the subjects rather than to magnetic or any other form of force communicated by the operator.

We firmly believe that this simple explanation was the correct one then, and is correct still. We have never yet seen nor heard of any phenomena of the sort in question which were not fairly attributable either to the imagination or to some tangible cause which could be easily pointed out. A few years ago while studying the medical uses of electricity with one of the most eminent physicians of New York City, who was at that time in charge of the department of nervous diseases at the great Demilt Dispensatory of that city, we had abundant opportunity of testing the matter, and were fully satisfied with the results.

The physician referred to was at that time engaged in a series of experiments in what he termed mental therapeutics. Under the guise of animal magnetism he was experimenting upon the imagination of the patients who came under his care. Not a particle of medicine was used, nor any other remedial agent. The patient was simply made to believe that he was being treated by means of a powerful magnetic current; yet, as the Doctor frequently remarked, *the results were as good as under any method of treatment he had ever employed.* The same method was not adopted in all cases, but was varied according to individual peculiarities, the same general principles being followed, however, throughout the course of experiments. In some instances the patient was allowed to think that the magnetic virtue had been imparted to a certain very bad tasting but inert liquid of which he was, with much solemnity, directed to take exactly one drop once in twenty-four hours, just as the clock was striking twelve, and on no account to take a larger quantity, or to take it at any other time, as the consequences might be something terrible. The effect of infinitesimal doses was under these circumstances decided enough to gratify

the most enthusiastic advocate of high potencies. A solution of nothing in reality but a bad taste, potentized by the imagination of the patient, wrought wonders of which the most successful "magnetic healer" would be proud to boast. Yet there was no chance for the operation of any other force than the minds of the patients themselves. To the influence of the mind upon the body must be attributed all the so-called magnetic cures.

A careful study of the nervous system and of the nature of nerve force makes it very apparent that the only way in which one mind can operate upon another is through the senses. From all we *know* of the mind, its only avenues of knowledge are the seven senses. These may receive impressions from external objects and transmit them to the brain; but there is no other means known by which knowledge of any sort can be imparted. The idea that nerve force can be communicated through any other medium than nerves is not to be entertained for a moment by scientific physiology. The simplest experiments demonstrate the fact that nerve force, volition, mind impulses, or whatever the force may be called, can travel on nothing but nerves. For instance, suppose the nerves which control the hand be divided. The most powerful effort of the will possible is now utterly powerless to cause the hand to move or to show any sign of obedience to the mind. The ends of the divided nerve may be united by muscular fibre or other living tissue, but still the channel over which nerve force is wont to travel with such rapidity is wholly interrupted. The best conductors of electricity, a force more closely allied to nerve or mind force than any other, may be used to splice the divided ends, but still the result is the same. The divided nerve ends may be pressed together as closely as mechanical contact can be made, and yet there will be no transmission of force beyond the point of division. Before the connection between the brain and the hand can be restored, the ends of the nerve must grow together, there must be a restoration of the continuity of structure which was broken down in the severing of the nerves. When this is done, the nerve resumes its function. The nerve force travels over it with the same facility as before, and the hand is again under the domination of the will. The deduction is a very clear one that if the mind cannot control or in any way influence an organ which is actually a part of the body, through which the same blood flows which circulates in the brain, and the muscular and membranous and bony tissues of which are one with the rest of

the body, the only difference being the division of some of the nerves or force conductors,—if under these circumstances the mind or will is powerless to operate, then how can it be possible that it should have power to affect by mere volition objects which are remote from it, or even objects which may be touched by the outer surface of the body? There can be but one answer to this question. The brain can only operate through the medium of nerves.

But we shall be asked to answer several questions. Perhaps the most frequent query will be, "If this view be correct, how do you account for the magnetic influence which some persons seem to possess by which they can influence an audience so wonderfully, swaying their feelings at will?" We answer, there is no evidence that any person possesses such magnetic power. Individuals often possess wonderful powers of influence, and people differ much in this respect. One man will hold a large audience spell-bound for hours, while another can scarcely keep a half-dozen in their seats until he has finished. The difference consists, not in the possession of magnetism by one and its want by the other, but in the different manner in which the two persons address their hearers. Let the most powerfully "magnetic" speaker stand before an audience of persons who are both blind and deaf, and how much influence could he have over them? Not a whit. He might exert himself to his utmost, he might imagine himself a powerful generator of magnetism, and suppose himself to be throwing out oceans of magnetic force, but the result would be wholly negative. If a force of the kind supposed really existed, the persons situated under the circumstances described would feel its influence as really and as intensely as though they could both see and hear. This simple experiment would settle conclusively the question of magnetism in public speakers, and would make evident the fact that what is termed magnetism in these cases is simply the sum total of the qualities which go to make up a good speaker, especially the gestures, the expressions of the face and attitudes of the body, the quality and inflections of the voice, the personal appearance of the speaker, and like qualities, all of which appear to the senses and depend for their influence wholly upon the impressions thus made.

"Magnetic rubbers" effect their cures in two ways: by means of exciting the imagination of the patient, and by means of the vigorous rubbing to which they frequently subject their patients. It is particularly noticeable that this class of quacks never cure any organic dis-

ease. In many instances the maladies which they seem to expel as by magic are imaginary ills which do not really exist at all, except in the mind of the patient, or trivial functional disorders which are readily controlled by the mind when the patient is made to believe himself well. As a means of curing diseases through mental influence, the myth, "animal magnetism," is unrivaled, and as such it has done a great amount of good; but on the other hand the belief in this fallacy has done a vast deal of harm by diverting the minds of the credulous away from the true principles of hygiene and the healing art. Hence we believe that it ought to be thoroughly exposed and condemned. Whatever good there may be in appealing to the imagination as a means of cure can be utilized without resorting to any such quackery as is universally connected with the practice of "magnetic doctors."

Mind-Reading.—The recently developed phenomena of mind-reading, so called, have been taken by many as positive evidence of the existence of some hidden means by which one mind may communicate with another otherwise than through the medium of the senses. We have been much interested in the phenomena exhibited by persons professing to have this power, and have taken some pains to investigate them. We enjoyed the opportunity of being present, by invitation, at a meeting of scientists, clergymen, physicians, and lawyers, held for the purpose of testing the claims of the first mind-reader who appeared before the public, a few years since. The operation called mind-reading consisted in the operator's taking the hand of the person whose mind was to be read and pressing it firmly against his forehead, after having been securely blindfolded, and then leading him to some place in which the individual had previously secreted some object without the knowledge of the operator. In nearly every case this was done successfully, no matter how distant the spot nor how circuitous the route taken in secreting it. The operator claimed to put his mind in communication with that of the person with whom he was operating, and to learn by this means the location of the object. The result of the investigation was to show very clearly that the pretended mind-reader could not read the mind of any one but himself, and that he had no means of getting information except through the senses; but that he possessed an uncommonly fine sense of touch by which he could appreciate very slight, and to the individual operated with, involuntary, muscular movements. It was always necessary that the subject should keep his mind intently occupied with the object

during the whole experiment, otherwise it was never successful. This would naturally incline the individual to make the slightest resistance when moving in the direction of the object. This is undoubtedly the correct explanation of the mind-reading mystery. Dr. Geo. M.

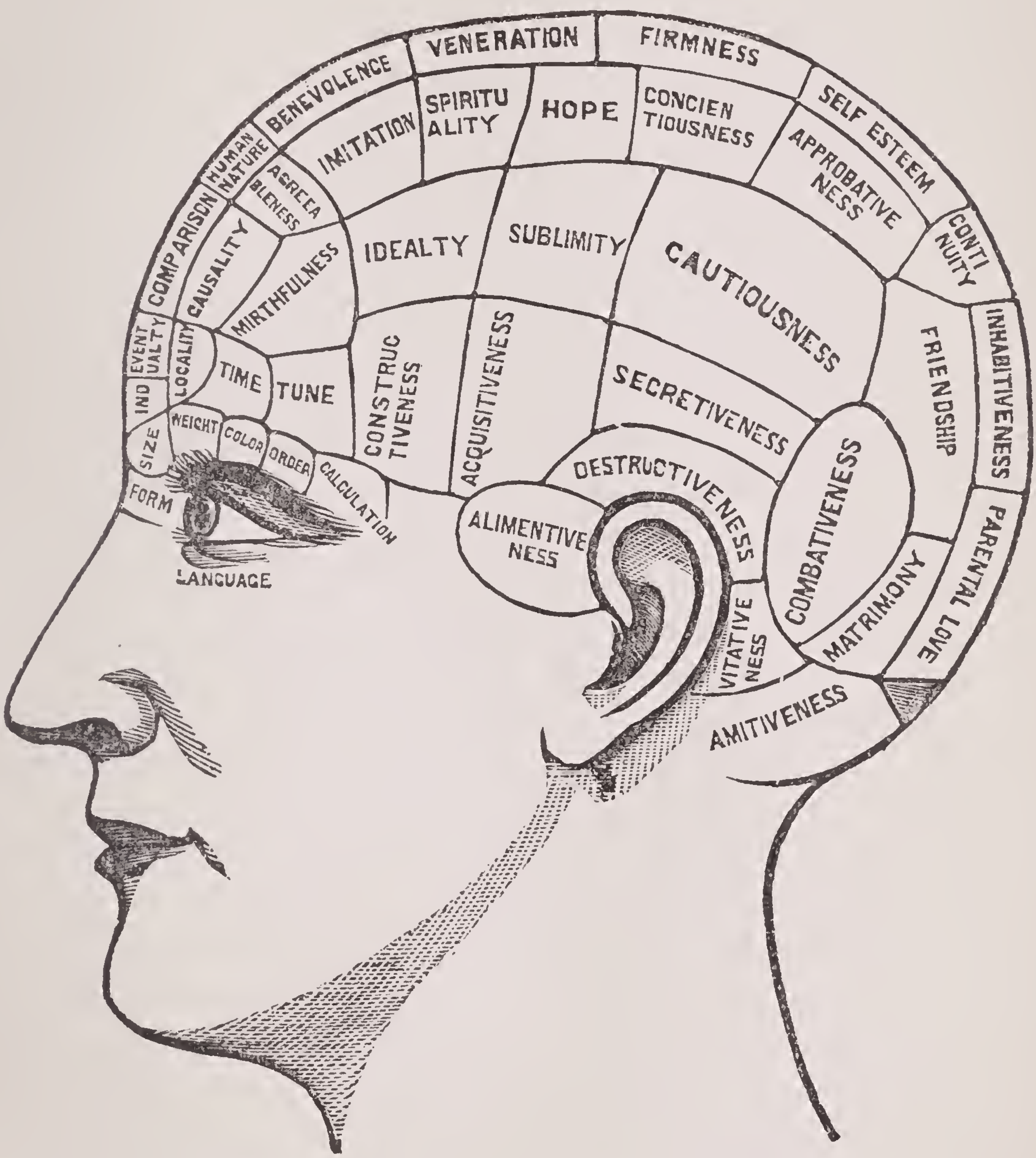


Fig. 76. A diagram showing the position of the various mental organs or "bumps" as located by phrenology.

Beard, of New York, and other eminent scientists, have carefully investigated the same phenomena, and have arrived at essentially the conclusions stated.

Phrenology.—Probably no psychological theory originated in modern times has had so great an influence upon the minds of the civilized people of the globe as has the theory originated by Gall and Spurzheim, known as phrenology. Taken together with physiog-

nomy, this theory attempts to determine a man's character by the external configuration of his skull and face. With the exception of a very few points which may be considered as quite well established by physiological and pathological observations, the theory must be considered as strictly empirical in character. As such, it must be subject to great changes. Since it cannot be said to have an anatomical basis, as all settled theories relating to the brain and nervous system must have, phrenology is certainly liable to great and very considerable changes, as the structure and functions of the brain are more thoroughly worked out by scientific research.

While there is much that is good in phrenology as taught by its ablest exponents, it is capable of being made an agent for great injury; and we have sometimes questioned whether almost as much harm as good was not done by it as it is generally used. Attracted by its novelty, thousands have studied it sufficiently to get a very slight smattering of the names and locations of the "bumps," and then, supposing they possessed all the requisites to make them competent to delineate the characters of their fellows, point out deficiencies and merits, etc., they have set themselves up as phrenologists, head-examiners, bump-feelers,—blunderers would be a much more proper term to attach to them,—when in fact they hardly possessed intelligence and mother-wit enough to become first-class barbers. The amount of trash which has been retailed about the country, especially in the rural districts, under the name of phrenology, is appalling. The harm that these charlatans do is incalculable. They fumble the heads of those who visit them, assume a wonderfully wise look, and then proceed to deal out to them a character according as their fancy dictates, or as will the best serve their purpose. Even when a man has sufficient information and experience to enable him to form a nearly correct estimate of a person's character, he may still be utterly unqualified to give the proper advice to individuals respecting the best course to pursue to remedy their defects. The business of giving advice to people concerning the work of reforming depraved characters, or correcting natural deformities of mind, mental and moral, is certainly second to no other in which a human being could be engaged, and ought to be attempted only by one who is in the most eminent degree qualified for the work. The problems which come before a physician who deals with the sick and disordered body are the simplest possible compared with those which pre-

sent themselves for solution to those who profess to be the physicians of the mind. Bad advice given by such an individual may do an incalculable amount of harm, as we have had occasion to observe in more than one instance. We have known cases in which persons who had lived happily for some time in the relation of husband and wife have suddenly discovered that they were wholly uncongenial and incapable of being happy together after going to a phrenologist and being told that they were not adapted to each other. Not long since a young man rushed into our office in most precipitate haste, having hurried much as he knew we were about leaving to make a professional visit. He carried on his face a look of the most profound anxiety. There was evidently a real trouble on his mind. As we were about going out he begged us to stop just one moment. We inquired if he was sick. "Oh, no," he said, "but I must see you just one moment." "Is some one else suddenly taken ill?" we asked, really feeling some little alarm, as he appeared so solemn and anxious. "No one is sick," he replied, "but I want to see you a moment to find out what I am good for." We were puzzled and asked for an explanation, which he promptly made by saying that he had just made a visit to a phrenologist who informed him that he had made a mistake in choosing the life-work for which he was fitting himself, the gospel ministry, and that he should prepare himself for a physician instead. The young man was much agitated in reflecting that so much time had been lost, and wanted to begin at once in his proper sphere if he could do so. We quieted his fears when we learned the cause, advised him to pay no attention to the counsels of his unwise adviser, and to pursue the even tenor of his way as before. He was manifestly unfitted for the work of a physician, though he had a great love for books, delighted in the study of language, was highly conscientious, and very desirous of doing good to his fellow-men. His lack of power to adapt himself to circumstances, and especially his want of ingenuity either mechanical or otherwise, clearly indicated that almost any other calling would be better fitted to him than that suggested by his adviser, who charged him a half-dollar for counsel which would have made his life a failure had he followed it. Upon inquiry we learned that the self-styled phrenologist had condemned his plan to fit himself for the ministry on account of his not possessing the phrenological sign of large language, although in fact he had a most excellent memory of words, having already acquired good command of three modern lan-

guages. The work of such men is damaging to the world, and far more so than they have any idea themselves.

We believe that phrenology in the hands of those who make it a specialty has been carried to an extreme; that claims are made by its advocates of powers which they do not and cannot possess. It is this, in fact, which has made the art,—it can hardly be called a science as yet,—obnoxious in the eyes of the great mass of scientists. Seeing that some claims are preposterous, they have neglected to investigate or give credit to any part of what is claimed. The many investigators who are now at work upon the cerebrum, examining its structure with the closest scrutiny of the microscope, and its functions by means of experiments upon living animals the nearest like man in their anatomical structure, will undoubtedly develop in time some facts bearing on this subject which will place what is true of the present phrenological doctrines upon a strictly scientific basis, and will add to them such elements as they lack of the completeness and definiteness which is required for a thoroughly symmetrical system of psychological science.

HYGIENE OF THE BRAIN AND NERVES.

As the brain and nerves are the controlling parts of the system, it is evident that upon the preservation of their health must depend in a very great measure the health of the whole body. A man whose brain and nerves are diseased cannot be healthy otherwise; neither is a person whose nervous system is in a healthy condition likely to be diseased otherwise. The marked increase in nervous affections of late years has become so noticeable that almost every medical writer calls attention to it, and this fact makes especially important the consideration of the laws which relate to the healthy action of this part of the body. The nervous structures are the most delicate of all the elements of the body; and when we consider the additional fact that they are subjected to more constant use than any other set of tissues, it certainly is not surprising that they should be specially subject to disease; but the great dependence of all other parts of the body upon the nerves makes it still more important that their integrity should be preserved.

Necessity for Mental Exercise.—Nerves as well as muscles require exercise to promote their growth and insure their development. That both brain and nerves are capable of development by exercise, and that development of these structures is largely dependent upon proper

exercise, are facts too well established to require proof by systematic evidence in this connection. Every-day experience convinces us of the fact. In the sharp contests of mind with mind in the battle for existence and the strife for fame, riches, and worldly honors, the mind which has been the most carefully trained to efficient action, which has by mental gymnastics learned to exercise to advantage its powers, always comes off victorious. It is not essential that the training should have been given in a school, or that the mental exercise should have been practiced in an academy or a college ; the farm, the workshop, the forest, or the coal-pit may have been the training-school or the gymnasium, but the work was done, and in such a manner as to secure a satisfactory result, and that is all that need be asked.

Mental exercise lies at the foundation of mental growth and mental health, and indirectly, we believe, it furnishes a firmer basis for muscular and general physical health than can be attained without it. The commonly received notion that mental work is harmful and incompatible with physical health we believe to be a gross and pernicious error. Our college students, male and female, who break down in health just as they have finished their studies, or before they have completed their course, are not victims to mental overwork, as a general thing. The same may be said of the great army of valetudinarian clergymen, lawyers, merchants, and others whose occupations are sedentary while involving considerable brain-work. In the great majority of instances, the failure of health in these cases is the result of flagrant violations of the commonest laws of health, such as deficient muscular exercise, bad food, late hours, fashionable dissipation, and, most of all, mental worry. The student hives himself up in his close study, probably smokes from three to a dozen cigars a day, lives upon the poorest boarding-house fare, and takes only just such little muscular exercise as he is compelled to do in going to and from his classes. Soon he finds his head dull, and he begins to worry because he is troubled to master his lessons. Now instead of gaining mental strength by his daily exercise, he is each day wearing out the vitality and wasting the very substance of his poorly nourished brain. Mental worry is corroding his intellectual powers, and he will sooner or later break down, a chronic invalid, and mental work will get the credit. In a similar way the clergyman, the lawyer, the politician, the merchant, breaks himself down. Thousands suffer with what is called "softening of the brain," when that organ is wholly intact except so far as it suffers through sympathy with other diseased organs, the whole trouble being in the stomach and liver.

This subject is so generally misunderstood that we deem it worth while to devote considerable space to it, and hence we will call attention to a few facts in support of these views, which we have for several years advocated in various ways, chiefly in lectures and through the journal of which we have had the editorial charge.

1. There is nothing in mental work which should make it especially liable to break down the constitution. On the other hand, it is well calculated to insure the highest degree of health. Since all the force manifested in the body originates in the nerve centers, chiefly in the brain, it is evident that the more vigorous the brain, the more vigorous the manifestations of force in the organs dependent upon it. And this is just the condition produced by mental labor. The brain grows in strength and vigor under exercise, and hence becomes capable of sending out more vigorous impulses to the various parts of the body dependent upon it for supplies of force.

Mental exercise is also agreeable to those who devote themselves to it. Authors, philosophers, poets, lawyers, enjoy their work, if successful in it; and only those who are successful, at least in a moderate degree, continue these pursuits. The same cannot be said of the mere mechanic or artisan who toils almost as mechanically as the machines which he employs. The poet loves his work and is loth to leave it. The hod-carrier gladly drops his hod and rejoices that his daily task is ended when the work bell announces the time at which he is allowed to stop. The muscle laborer seldom works unless necessity demands it; while the brain-worker keeps on toiling as arduously as ever long after the accumulation of a competency makes his labor wholly unnecessary. We speak now, of course, of pleasant mental pursuits which are not disturbed by mental worry. The harrowing anxiety of the stock-broker or the gambler is not conducive to health, mental or physical.

2. Brain-workers are long-lived. This statement will be almost certain to be disputed, and so we must fortify it with incontrovertible facts, which, fortunately, we are well able to do. Quite a little research has been made upon this question within the last few years, and with most decided results in favor of mental workers.

According to an eminent French writer, Gorgias the rhetorician lived to the age of one hundred and eight years, "without discontinuing his studies and without any infirmity." Epimenides, one of the seven "wise men," lived to the great age of one hundred and fifty-four. Hippocrates, the father of medical literature, who was a diligent student

and wrote voluminous works, many of which are still extant though penned more than twenty centuries ago, lived to the age of ninety-nine; and his master, Herodicus, attained the age of one hundred. Galen, one of the most celebrated physicians of antiquity, wrote three hundred volumes, many of which are consulted as authorities at the present day, and lived to be nearly a hundred years of age. Cornaro lived to the age of one hundred, though of a frail constitution, and did vigorous mental work for seven or eight hours a day until his death. The great Stoic, Zeno, a diligent student, lived to the great age of ninety-eight, when he put an end to his life while in the full possession of his faculties because he had received what he took to be an admonition that his time to die had come. Socrates was murdered at seventy-one in the prime of life. Pythagoras, Pindar, Quintilian, Chrysippus, and Thucydides lived to the age of eighty or upwards. Polybius and Plato died at eighty-one. Xenophon, Diogenes, and Carneades died at ninety. Euripides lived to the age of eighty-five. Anaxagoras died at seventy-two, and Aristotle at sixty-three. All of these men were hard-working students of nature and philosophy. They were the representative men of their times. They did work which has resisted the ravages of time and come down to us through the Dark Ages, in many respects work which cannot be surpassed in excellence, and often is unapproachable in its perfection. Yet all of them lived to almost double the present average length of life. Their average length of life is more than ninety-one years, which certainly does not militate against mental work as conducive to longevity.

Dr. Madden, in an able work on the "Infirmities of Genius" gives twelve tables of noted men of twenty names each, which sum up as follows:—

	AVERAGE AGE.
Twenty Natural Philosophers,	75
" Moral Philosophers,	70
" Sculptors and Painters,	70
" Authors on Law, etc.,	69
" Medical Authors,	68
" Authors on Religion,	67
" Writers on Language,	66
" Musical Composers,	64
" Miscellaneous Authors,	62
" Dramatists,	62
" Writers on Natural Religion,	62
" Poets,	57
Average of these Two Hundred and Forty Brain-Workers,	66

That the unusual longevity of the brain-workers already referred to was not due to the fact that they lived at an earlier age of the world is evidenced by the fact that the same characteristic is noticeable among mental workers of the present day, as is shown by the following table, which is made up of men who have lived in recent times :—

Bacon, Roger,	78	Young,	84
Buffon,	81	Ferguson,	92
Galileo,	78	Kant,	80
Copernicus,	70	Reid,	86
Lowenhoeck,	91	Goethe,	82
Newton,	84	Crebillon,	89
Whiston,	95	Goldoni,	85
Erasmus,	69	Watt, James,	83
Bentham,	85	Hobbes,	91
Mansfield,	88	Locke,	72
Le Sage,	80	Stewart, D.,	75
Wesley, John,	88	Voltaire,	84
Hoffman,	83	Cumberland,	80
Pinel,	84	Southern, Thomas,	86
Claude,	82	Coke, Lord,	85
Titian,	96	Wilmot,	83
Franklin,	85	Rabelais,	70
Halley,	86	Harvey,	81
Rollin,	80	Heberden,	92
Waller,	82	Michael Angelo,	96
Chalmers,	83	Handel,	75
South, Dr.,	83	Hayden,	77
Johnson, Dr.,	75	Ruysch,	93
Cherubini,	82	Winslow,	91
Herschel,	84	Morgagui,	89
Laplace,	77	Cardan,	76
Linnæus,	72	Fleury, Cardinal,	90
Metastasio,	84	Auguetel,	84
Milton,	66	Swift,	78
Bacon, Lord,	65	Watts, Dr.,	74

The average age of all the above-named persons, sixty in all, is a little more than eighty-two.

It is very evident that experience is decidedly against the commonly received notions on this subject. Though further evidence is scarcely needed, we may add the following from a recently published paper by Dr. Geo. M. Beard, of New York, well known as an eminent electrician and neurologist :—

"I have ascertained the longevity of five hundred of the greatest men in history. The list I prepared includes a large proportion of the most eminent names in all the departments of thought and activity.

"It would be difficult to find more than two or three hundred illustrious poets, philosophers, authors, scientists, lawyers, statesmen, generals, physicians, inventors, musicians, actors, orators, or philanthropists of world-wide and immortal fame, and whose lives are known in sufficient detail, that are not represented in this list. My list was prepared, not for the average longevity, but in order to determine at what time of life men do their best work. It was, therefore, prepared with absolute impartiality; and includes, of course, those who, like Byron, Raphael, Pascal, Mozart, Keats, etc., died comparatively young. Now the average age of those I have mentioned, I found to be 64.20.

"The average age at death at the present time, of all classes of those who live over twenty years, is *about fifty*. Therefore the greatest men of the world have lived longer, on the average, than men of ordinary ability in the different occupations, by fourteen years; six years longer than physicians and lawyers; nineteen or twenty years longer than mechanics and day-laborers; from two to three years longer than farmers; and a fraction of a year longer than clergymen, who are the longest-lived in our modern society."

Dr. Beard states among other conclusions at which he has arrived as the result of his investigations,—

"1. That the brain-working classes—clergymen, lawyers, physicians, merchants, scientists, and men of letters—live very much longer than the muscle-working class.

"2. That those who follow occupations that call both muscle and brain into exercise, are longer-lived than those who live in occupations that are purely manual.

"3. That the greatest and hardest brain-workers of history have lived longer on the average than brain-workers of ordinary ability and industry.

"4. That clergymen are longer-lived than any other great class of brain-workers."

Proper Mode of Developing the Minds of Children.—That there is a right way and a wrong way of dealing with young minds in order to develop them so as to fit them for their highest usefulness in after-years, is patent not only from the nature of things, but from the unsuccessful results to be seen in the illy developed minds of thousands

of men and women whom we daily see trying in vain to make their way well in the world against the numerous obstacles placed in their pathway, the most insurmountable of which are the results of bad training.

In a great many instances, perhaps in the greater share of cases, the process of education is a process of perversion from first to last. The child, when put to school at an age altogether too early, instead of being led along the path marked out by Nature for him to walk in, in his pursuit of knowledge, is set to work, or gone to work at, in a manner the most remotely removed from the natural order. Instead of beginning where Nature does, with the development and training of the perceptives, the sources of knowledge, thus teaching the learner at the outset how to observe thoroughly and accurately, in nine cases out of ten the teacher begins by giving the child instruction which can have no other influence than to lessen his reliance upon his own powers of observation and perception, and lead him to take such information as is dealt out to him unquestioningly, and without being able to see any natural relations between the knowledge imparted and that which it is supposed to represent. Thus his education continues, his mind being dwarfed by improper methods, and his body injured by unnecessary and harmful confinement, until the child either dies, becomes an educated dolt, or perchance, from natural brilliance of intellect, breaks away from the fetters forged around him and begins to think for himself at last, and then really begins to learn.

The majority of children do not enjoy school-life. It is irksome to them. It is actually repulsive, and naturally so. Learning is made hard work, when for them it ought to be made play. Children do not generally like work, but they do love play; and if instruction could be imparted to them through methods which would be to them play, a great gain would be made. The efforts of the managers of Kindergartens in this direction are certainly commendable, and we hope they will be successfully introduced into every city and village in the land. We heartily concur in the following observations on this subject made by Dr. Richardson, one of the most eminent medical scientists of Europe:—

"For children under seven years of age the whole of the teaching that should be naturally conveyed should be through play, if the body is to be trained up healthily as the bearer of the mind. And it is wonderful what an amount of learning can by this method be at-

tained. Letters of languages can be taught; conversations in different languages can be carried on; forms of animal life can be classified; the surface of the earth can be made clear; history can be told as story; and a number of other and most useful truths can be instilled without ever forcing the child to touch a book or read a formal lesson."

School Cramming.—Nothing could be more unscientific nor more unphysiological than the popular methods of instruction in vogue in most of our schools for youth as well as in those for small children. The idea of education entertained by the average teacher is that it consists in infusing into the mind of the pupil the largest possible amount of knowledge which it can be made to contain. Little is thought of the necessity for thorough and systematic discipline of the mental faculties. Consequently, it is generally the case that the student's entire experience at school or college is one continual course of perversion. Instead of being taught how to think and study to the best advantage, how to investigate for himself, how to originate ideas and to become mentally independent, the student is continually discouraged by the methods employed by his instructors, from any attempt at originality or independence of thought, and thus becomes a dogmatic mental dwarf. We sincerely hope that the day will come when our educators will regard the primary object of schools to be culture and training of the human body, mentally, morally, and physically.

No system of education can be complete which does not give due prominence to the pupil's culture morally and physically, as well as mentally. The acquisition of knowledge should be regarded not as the primary object of education, but as a useful incidental result, necessitated by the nature of the discipline to be acquired.

Students should be thoroughly imbued with the idea that the object of their school-work is not so much to impart to them a knowledge of facts, as to teach them how to acquire facts, how to investigate, how to compare, how to reason, how to utilize knowledge after it has been acquired. The methods of education generally followed in our colleges, fill young men with facts, and pack their craniums with the ideas of men who lived two thousand years ago, and then graduate them and send them out into the world destitute of even a modicum of practical knowledge, without the ability to use the facts which they have gained. Such men have much knowledge, but are unable to use it to practical advantage; and a score of them are of

less real use to the world than one practical man whose fund of information is almost infinitely smaller, but who possesses the faculty of utilizing knowledge. There is great need of reform in our educational institutions, and we are glad to see some evidences of improvement in this direction. The times call for practical men, and the public mind is being aroused to ascertain why there is so great a scarcity of men of this class. We hope the inquiry will continue, and that the agitation of the question which has begun, will increase until conservatism, prejudice, and dogmatism, which are the chief obstacles against educational reform, are swept away by the rising tide of public opinion in favor of progress in this direction.

Unsymmetrical Mental Development.—A marked tendency of the times is toward the selection of specialties, not only in the professions, but in all departments of life. This seems to be necessary on two accounts: 1. The accumulation of facts in the various departments of human knowledge is so great that a single mind cannot hope to grasp all. The best an individual can do is to become thoroughly conversant with one or two arts or sciences. Human life is not long enough, even if the capacity of the brain were sufficient, which there is reason to doubt, to master all that is known in the various subjects of study. 2. Some persons are born with a peculiar fitness for certain pursuits, mental or muscular, or both, and hence they will be most likely to succeed in those particular pursuits. This tendency, although it seems to be a natural outgrowth of the present state of society and of the world, and a necessary result of a high grade of culture, is nevertheless detrimental to the individual. While it benefits society as a whole, making it more perfect than it could otherwise be, the gain of society is at the expense of its individual members, or of some of them at least. By the undue development of certain faculties to the neglect of others, the sum total of brain force is weakened, and the brain becomes a monstrosity, and the mind a distortion. It is more than probable that this specialization of labor and of mental development is one of the causes which induce, at first eccentricity and afterward actual insanity, which is but one step removed from well-marked eccentricity. It is far better for each individual to acquire as equable a development as possible, mentally, physically, and morally; each one should endeavor to acquire as much as possible of this equable culture, as it will add force and endurance to the mind, even should

the individual afterward become a specialist in some branch of knowledge.

Evils of Excessive Brain-Labor.—While a proper amount of brain-labor is in the highest degree wholesome and conducive to longevity, as already shown, too much mental work is harmful in a high degree. The brain wears rapidly, and requires abundant time for rest and repair in sleep; when this is supplied, almost any amount of work may be performed which is possible to the individual. Brain-worry wears much faster than work, and to it should be attributed much that has been charged to brain-work. Physiologists have shown that three hours of severe mental labor exhausts the system as much as ten hours of severe physical labor, which leads to the conclusion that less time should be spent in mental labor than is usually spent in muscular labor between the intervals of rest. The student or professional man who goads his brain into activity when it is exhausted by want of sleep or long and severe labor, commits a crime against himself. The strongest mind will eventually break down under such usage. When the brain is weary, and thought is laborious, rest is required, and it should be secured.

Pernicious Effects of Stimulants and Narcotics.—Brain-workers are of all classes the most strongly tempted to make use of excitants to enable them to obtain from their tired nerves a little more work than they are capable of doing with safety. Alcohol, tobacco, tea, coffee, and chocolate are all used for this purpose, and with apparent advantage in some cases, temporarily at least. But the advantage is only apparent. These drugs, and all others which operate in a kindred manner, are deceptive; they make a person believe he is not tired, when he is exhausted; they make him think he is warm, when he is really cold. They make him believe he is strong, when he is weak. Their use is most pernicious in its effects, since it more than doubles the danger from overwork. When in a natural condition, a man can tell by his feelings when he has gone to the full limit of his powers of endurance; but when his nerves are stupefied by alcohol or tobacco, or exhilarated with tea or coffee, he has no landmarks; he is at sea, and is certain to meet with disaster and shipwreck unless he change his course. This subject is more fully considered in a chapter devoted to the subject, to which the reader's attention is invited.

THE ORGANS OF SPECIAL SENSE.

In such low forms of life as the mussel and the earth-worm, what little sensation is present is of a very simple kind. As we rise higher in the scale of being, the general property of sensibility is modified to meet the wants of the higher order of existence, and special properties are developed. In man, in whom is found the highest type of sensibility, there are, in addition to the general sensibility which pervades the whole body, seven varieties of sensation, termed the special senses. Formerly there were enumerated but five, *hearing*, *seeing*, *smelling*, *tasting*, and *feeling*; but two others have been added within a few years, the *sense of temperature*, and the *muscular sense*, or the *sense of weight*. Each of the first five of these requires a special organ for its manifestation; to the study of these organs of the special senses and their functions we will now give our attention, considering the simpler organs first, and so gradually approaching the more complicated, which are undoubtedly the most wonderful exhibitions of delicate organization and perfect adaptation of means to ends in the body.

THE SKIN.

The skin contains the organs of touch, but cannot itself be called the organ of touch, as it performs several other functions, some of which are fully as important as this. The mucous membrane of the mouth and nose also possesses tactile sense. The skin is composed of two principal layers, which are easily separated, after death, by maceration in water. The inner of the two is the true skin, or *cutis vera*, in which are located all the organs and elements to which the functions of the skin are due. The basis of the structure of the skin is a dense network of elastic fibres, among which are closely interwoven minute blood-vessels, nerve filaments, and lymphatic or absorbent vessels. The skin also contains little pockets, or follicles, from which the hair grows, each hair from a single follicle. Closely connected with the hair follicles are small glands, the function of which is the production of fatty or sebaceous matter. Here are also found the perspiratory or sweat glands, which will be more accurately described elsewhere. Another interesting element of the true skin is involuntary muscular fibre, the contraction of which draws the skin into the peculiar condition known as goose-flesh.

The *cuticle*, or *epidermis*, is wholly made up of cells, which are produced by the true skin beneath. As the cells grow older they become shrunken and dead, and are gradually pushed out to the surface, becoming dried and falling off as new cells are pushed out beneath. These dead cells give to the epidermis a horny character, and when viewed with a microscope its outer layers are seen to be composed of delicate little scales, which are the dead cells referred to. The lower part of the epidermis contains colored cells, upon which the color of the skin in different persons and different races depends. In the negro these cells are abundant, giving to the skin a black color. In the lighter races they are less abundant, there being very few in the skin of the Caucasian, and none at all in the albino, whose transparent epidermis shows very clearly the red color of the living tissues beneath, with their abundant supply of blood-vessels.

The thickness of the cuticle varies in different parts of the body and in different persons. Its use is to protect the true skin beneath.

The structure of the skin is very well shown in Plate IV.

The nerves of touch terminate in the true skin, in a variety of ways. It is probable that in the majority of instances they end in the hair follicles already mentioned; but in the parts of the body in which the sense of touch is most acute, as the hands, a special arrangement to give the greatest possible delicacy is provided. This consists of what is known as tactile corpuscles, which are cone-shaped, corpuscular, resisting bodies located in the papillæ of the skin, as shown in the plate. The nerve fibres which convey tactile impressions terminate in these bodies, after coiling two or three times among them. The resistance which the corpuscles afford, adds greatly to the delicacy of the sense of touch. It is their presence in large numbers at the ends of the fingers which gives to this part of the skin such accuracy of touch. More than one hundred of these corpuscles were counted in a space near the end of a finger $\frac{1}{50}$ of an inch square, which would make more than 200,000 to the square inch.

The Sense of Touch.—Of the seven special senses this is undoubtedly the most simple; yet through it we learn many of the most important facts which we possess concerning external objects. We learn by it such properties of objects as size, form, and character of surface as to smoothness or roughness. The sense of touch greatly assists the other senses in acquiring correct ideas of the nature of bodies. We are rarely fully conscious of our real dependence upon this sense, or of the degree

to which it may be developed, until deprived of some of the other senses. especially sight. Numerous examples are given of persons who, upon losing their sight, have been enabled to develop their sense of touch to such a degree as to be really marvelous. Probably one reason for this remarkable increase in the delicacy and efficiency of touch is the concentration of the attention upon it when the sight is absent from birth, or has been destroyed.

The sense of touch differs greatly in delicacy in different parts of the body. The acuteness of the tactile sense in any part may be readily tested by observing the distance at which two pin points may be placed from each other without being recognized as two distinct objects. For example, two points applied in this way to the hand, will be recognized as two when but a slight distance apart; while upon the back they may be removed some considerable distance without being distinguished as more than one object. In this way the whole skin has been tested, the results showing that of all parts, the tip of the tongue is the most sensitive, recognizing points which are not more than one-twenty-fifth of an inch apart. The tips of the fingers rank next in sensibility, distinguishing objects which are no nearer to each other than one-seventeenth of an inch. From the tips of the fingers the acuteness of touch rapidly diminishes as we recede, being represented by a distance of one-seventh inch at the portion of the finger next the palm of the hand, one-third on the back of the fingers, three-fifths on the back of the hand, two-thirds on the skin of the throat, one and one-half inches on the sternum, and two inches at the middle of the back. The cheek is much more sensitive than the back of the hand, recognizing objects at one-third of an inch. Objects are recognized on the dorsum of the foot at a distance of one inch.

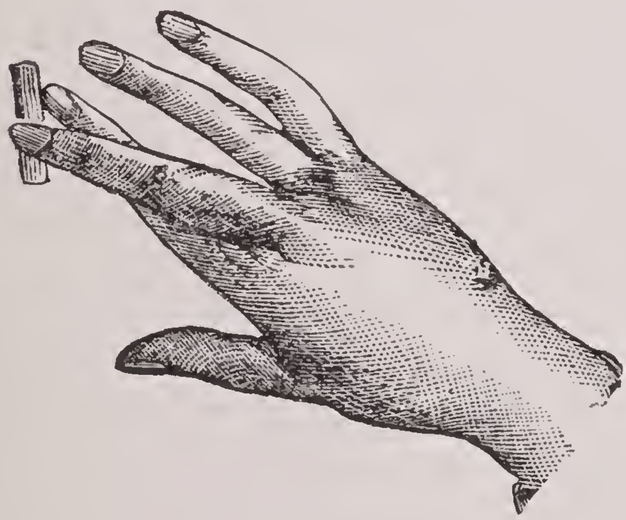


Fig. 77.

The sense of touch may be regarded as one of the most reliable of all the senses; yet we are liable to deception by it if impressions are received in a manner different from that in which they usually are. This fact is illustrated by an experiment the origin of which dates back to Aristotle. If two fingers be crossed as shown in Fig. 77, and a small

object placed between the ends, the impression will be that two objects are felt. The reason of this evidently is that by crossing the fingers the two sides of the fingers opposed are such as have been taught to distinguish separate objects, and they tell the same story which they have been educated to tell, notwithstanding it does not agree with the facts. This shows clearly that the action of the nerves as well as that of the brain is largely the result of education. An illustration of the same fact is to be found in a surgical operation sometimes performed for the restoration of a nose which has been destroyed by accident or disease. In this operation the skin of the forehead is brought down and made to grow into the form of a nose ; but the sense of touch still retains the old position, so that when the new nose is touched, the impression is conveyed to the brain that the forehead has been touched. After a few months, however, the sense of touch is educated to recognize its new position, and the difficulty is overcome.

So with persons who have suffered amputation of a limb ; they continue to feel the fingers or toes for some time. Persons have even claimed to feel actions which really occurred in amputated limbs. Such claims are, however, wholly based on the imagination. The phenomenon is due to the fact to which attention has just been called, that the nerves form the habit of carrying impressions from certain points, and whenever irritated in any way, carry the same impression even if they are no longer connected with the original points. The deception gradually fades away, the nerves by degrees becoming accustomed to their new condition, so that the amputated limb seems to grow gradually shorter and shorter until its real condition is correctly recognized by the nerves.

THE MUSCULAR SENSE.

The sense by which weight is appreciated, or the muscular sense, is supposed to be located in the muscles. It is evidently distinct from the sense of touch, because the tactile sense may be wholly obliterated by disease while the muscular sense remains.

It is this sense which enables a person to judge of the weight of an object, and to adjust his outlay of strength to the object to be lifted. If it were not for this sense our movements would be very irregular and spasmodic.

THE SENSE OF TEMPERATURE.

This sense bears a close relation to the tactile sense, but is also proven to be different because it often exists when the sense of touch has been lost by disease, and is sometimes lost while the tactile sense remains intact. By means of this sense we are able to determine degrees of temperature within certain limits. When an object which is very hot is brought in contact with the skin, the sensation is of pain, rather than of heat. It is a curious fact that the effect upon the nerves of sense as well as upon the tissues is essentially the same whether the object be very hot or very cold.

The thermal sense is not an accurate measure of heat, since, as with all other forms of sensibility, its impressions are relative rather than positive. This is well shown by a simple experiment. Place in three vessels a quantity of water of different temperatures, making that in the first vessel very cold, that in the third very hot, and that in the second intermediate between the two. Place one hand in the cold water and the other in the hot, holding them in the water one or two minutes. Then put first one hand and then the other into the middle vessel of water at the medium temperature. The curious fact will be observed that each hand tells a different story about the temperature of the water in this vessel. The one which has been in the hot water says it is cold, while the other hand, which was removed from the vessel of cold water, declares that it is warm. From this experiment it is clear that our ideas of temperature gained through the thermal sense are only relative.

It is also worthy of notice that the apparent temperature of objects depends in a great measure upon their character. An object which is a good conductor of heat seems to possess a much higher temperature than one which is a poor conductor, although the absolute temperature of both may be exactly the same. It is this fact which causes metals and liquids to seem warmer at a given temperature than gases and solid objects composed of such poor conductors as wood, straw, hair, and similar substances. Liquids of a higher temperature than 120° can be borne but for an instant, while vapor of 140° or 150° can be endured without pain, and the whole body may be immersed in hot air at a temperature of 250° and upward with impunity. We have remained some minutes in a room of this temperature without the slightest injury; and persons have been known to endure a very much higher temperature in perfectly dry air.

THE SENSE OF TASTE.

The sense of taste, or gustatory sense, is located in the mucous membrane of the tongue, being attributable to two nerves, one of which is distributed in the anterior portion of the organ, and the other in the mucous membrane of the back part of the tongue and mouth. The terminal filaments of these nerves seem to end in little prominences with which the membrane is closely studded, which are known as *papillæ*. The larger of these are supposed to be devoted to the sense of taste, while the smaller contain nerves of touch and of the thermal sense, both of which forms of sensibility are possessed by the tongue in a high degree, especially by its tip, which possesses the most delicate tactile sense of any part of the body. This portion is not quite so sensitive to taste as the posterior portion of the organ.

The sense of taste, like the senses of touch, weight, and temperature, is exercised only upon bodies which come in immediate contact with it. In the case of taste, however, mere mechanical contact is not sufficient. An object to be appreciated by the gustatory sense must be dissolved, so that it may come in direct contact with the nerves of taste by penetrating the papillæ in which they terminate; hence, any substances placed upon the tongue when dry, will not be tasted until dissolved, if at all; and insoluble substances evidently can possess no gustatory properties. When the tongue becomes "coated" or "furred," as it often does in sickness, the sense of taste is greatly lessened in acuteness, which accounts in a great degree for the insipidness of foods and drinks so often complained of at those times.

Physiological experiments seem to show that the sense of taste is confined to the tip, edges, and back portion of the tongue, and the back portion of the roof of the mouth and the soft palate, being absent from the lips, gums, middle of dorsum or back of tongue and its under side, and from the front part of the roof of the mouth.

Tastes are classified as acid, saline, bitter, and sweet, though it is evident that there are many flavors which are not included in this classification, and which cannot be accurately described. Of these different tastes it is curiously observed that those of a saline and bitter character are best appreciated by the back portion of the tongue, and sweet and acid flavors by the anterior portion. Some physiologists claim that acids are best appreciated by the sides of the tongue. All of these various tastes seem to be increased by friction of the

tongue against the roof and sides of the mouth, which is probably due to the diffusion of the sapid substance.

Taste Aided by other Senses.—Many of the properties of substances appreciated in the mouth prove, upon careful examination, to be recognized by other senses than that of taste, although credit is given to the latter. For instance, people often speak of astringent, oily, mealy, watery, smooth, burning or pungent, and cool tastes, when in reality these are not tastes at all, but are properties recognized by the senses of touch and temperature. So, also, substances are spoken of as having strong tastes when they have very little taste indeed, but are simply smelled when in the mouth. Sight is also an aid to the sense of taste by exciting agreeable anticipations.

The Uses of Taste.—Besides being a source of gratification, the sense of taste is useful as a guide in the selection of food. As a general rule, substances which are unpalatable, repugnant to the taste, are unwholesome. There are, it is true, cases of individual idiosyncrasy in which the sense of taste rejects articles which are really wholesome; but even in these cases the taste may many times be a correct guide, as the digestive organs are in close sympathy with the gustatory sense and might resent the usually wholesome aliment on account of the same unexplainable peculiarity.

The taste is susceptible of education in a very high degree. Even the most repugnant substances may by degrees be made acceptable. Tastes vary greatly in different countries, one nation considering as a delicacy what would be most loathsome to others. For instance, nothing could be more repulsive to the palate of a Frenchman than the putrid flesh considered as a delicacy by some nations; and it is quite likely that the latter would consider equally disgusting the asafetida which the former sometimes employs as a flavor in his dainty dishes.

Electrical Excitement of the Sense of Taste.—The sense of taste may be excited by a current of electricity as well as by sapid substances. A very simple experiment will illustrate this fact. Place upon the upper side of the tongue a piece of brightly polished zinc, and upon the under side a large copper penny or a silver half-dollar, bringing the edges of the two metals together at the tip of the tongue. In a few seconds a very strong metallic taste will be experienced. If the positive pole of a battery be touched to the tongue, while the other is held in the hand, an alkaline taste will be experienced; and the application of the negative pole will produce a strongly acid taste. We

have frequently observed in practice that excitation of the nerve of taste is often felt by patients during the application of galvanism to other parts of the body.

THE ORGANS OF SMELL.

The organ of smell, or the olfactory sense, is located in the upper part of the nasal cavity, the mucous membrane of which part receives the branches of the olfactory nerve which are sent down from the olfactory bulbs—a portion of the brain located just above—through a large number of very small openings in the floor of the skull, provided for this purpose. The balance of the mucous membrane of the nose is supplied with branches from the general sensory nerve of the face, and has nothing to do with the sense of smell. The ends of the olfactory nerves are not imbedded in the mucous membrane as are the nerves of taste and the sensory nerves, but are exposed with a very slight covering of epithelium, so that they may receive more delicate impressions. Smell is produced by the actual contact of odorous particles with the nerve filaments. It seems also to be necessary that these particles should be brought to the nose suspended in the air; since the nasal cavity may be filled with rose-water, the odor of which is very marked, without exciting the sense of smell in the slightest degree. Although a certain degree of moisture is necessarily maintained, the presence of a large amount of fluid interferes with the function of smell altogether. In ordinary breathing, the air taken in through the nose passes only through its lower passages, and does not come in direct or immediate contact with the nerves of smell in the upper portion of the cavity; but odorous particles in the air reach the nerves of smell by diffusion of the air upward. By the act of sniffing, however, which is instinctively performed when we wish to intensify the sense of smell, the air is forcibly drawn up into the upper part of the nasal cavity, and thus brings a larger number of particles in contact with the olfactory nerve than in ordinary respiration.

We are able, by means of the olfactory sense, to appreciate a very great variety of odors, the number of which is so great as to make almost utterly impossible any attempt to classify them. These odors can not only be distinguished when presented separately, but also when mingled they can be recognized individually. The quantity of material necessary to excite the sense of smell is exceedingly minute. A single grain of musk will fill a room with its odor for many years without appreciably diminishing in weight.

It is a curious fact that mental impressions and associations are more closely connected with smell than with any other sense. Many persons are so susceptible in this regard that a very slight excitation of the sense with certain odors will cause them to faint.

Uses of the Sense of Smell.—In addition to affording a great amount of pleasure by enabling us to recognize the numerous delicate and pleasing perfumes which abound in nature, especially in the botanical world, the sense of smell apprizes us of unwholesome constituents in the air, and of our proximity to sources of injury to health. The olfactory sense thus protects not only the lungs and other respiratory organs, by enabling us to avoid irritating gases which might cause serious injury to the whole system, but it is also useful to enable us to judge of the properties of food, and to stimulate the appetite and the action of the organs of digestion. It is not true that all harmful substances possess bad odors, but it is almost universally true that substances possessing an unpleasant odor are not wholesome. The sense of smell is a valuable sentinel to the citadel of life, and ought to be carefully guarded and protected. It may be educated to a great degree of delicacy.

As a general rule the lower orders of animals possess this sense in a much more acute degree than man. Wild animals will scent their prey or their enemies at a great distance. The keenness of scent in the dog is marvelous. This doubtless depends largely upon the fact that in animals of this class the olfactory nerve is spread over a much larger space than in man. In barbarous tribes the sense seems to be much more highly developed than in civilized man. Humboldt, the great naturalist and traveler, states that the natives of Peru can distinguish in the dark between different races by this sense.

HEARING: THE AUDITORY SENSE.

The organ of hearing consists of three parts: 1. The *external ear,* a trumpet-shaped portion for collecting sounds; 2. The *middle ear,* or *tympanum,* a cavity separated from the external ear by a membrane resembling a drum-head in its character and use, and containing several delicate bones, or *ossicles,* which play an important part in the action of the ear; 3. The *internal ear,* or *labyrinth,* which contains the terminal filaments of the auditory nerve and delicate apparatus connected with the reception of auditory impressions of various kinds.

The External Ear.—The external portion of the ear consists of a framework of cartilage covered with skin, having a shape somewhat like that of a conch-shell. It is attached to the bones of the head in such a manner as to be easily movable within small limits. In lower animals the various movements admissible are produced by a special set of muscles for the purpose. In man these muscles are usually so slightly developed that they are capable of producing no perceptible motion, only in very exceptional instances.

Fig. 78. The Ear. The cut shows the External Auditory Canal, the Middle Ear with the Ossicles, and the Internal Ear.

The outer portion of the ear is connected with the middle ear by means of a slightly curved canal about one and one-fourth inches in length, across the bottom of which is stretched the outer boundary of the middle ear. This canal is lined by a continuation of the skin of the ear, which here becomes very thin and sensitive, and contains glands that resemble the sweat glands found in other parts of the skin but which here secrete a waxy substance called *cerumen*, of an intensely bitter taste, the probable object of which is to guard the ear against the entrance of insects. Numerous fine hairs here found doubtless assist in protecting the ear from insects, dust, and other foreign bodies. The ear-wax is usually produced in small quantity, and dries and falls from the ear in thin scales.

The Middle Ear.—The middle ear, or *tympanum*, is a cavity placed between the external and internal ears. Its structure is such as to remind one of a drum. The cavity consists of a little hollow in the temporal bone of the head, the outer side of which is bounded by a membrane which separates it from the outer ear and is known as the *membrana tympani*. Its inner side also presents an opening which is covered in a somewhat similar manner. The tympanum is not a closed cavity, as it communicates with the throat or back part of the nasal cavity by means of a small canal known as the *Eustachian tube*.

The Ear-Bones.—The middle ear contains in its cavity a chain of bones, three in number, reaching across from one side to the other. These delicate bony structures have received names corresponding to their different shapes. The first, being shaped like a mallet, is called the *malleus;* the second, from its resemblance to a blacksmith's an-

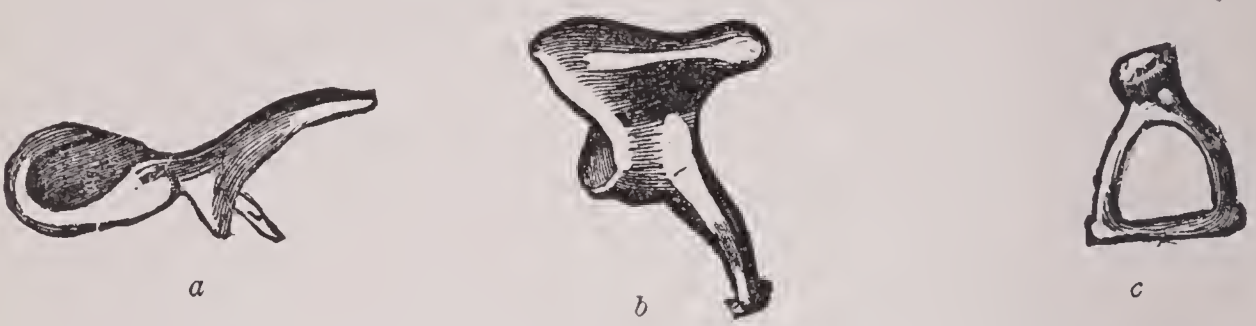


Fig. 79. Bones of the Ear. *a.* Malleus; *b.* Incus; *c.* Stapes.

vil, is known as the *incus,* which has that signification; and the third, from its resemblance to a stirrup, is called the *stapes.* The first of these bones is attached by its longer part, or handle, to the drum membrane. All the bones are connected by delicate joints, and the innermost bone, the *stapes,* fits into an opening in the opposite wall of the middle ear by which it is connected with the internal ear.

Connected with the ear-bones and the drum membrane are three delicate muscles, the smallest in the body, which by their action regulate the movements of these parts. Two of these are attached to the drum membrane, their use being to relax it and to render it tense, and the other to the *stapes.*

The Internal Ear.—This is one of the most delicate and complicated mechanisms in the body. Owing to its complex structure and tortuous canals, it is called the *labyrinth.* This is the most essential part of the auditory apparatus. It is placed in a hollow in the densest part of the temporal bone. It may be divided into three parts: 1. The *vestibule,* or ante-chamber; 2. The *cochlea,* or snail-shell; 3. The *semi-circular canals.*

The vestibule, semi-circular canals, and cochlea are all filled with a limpid fluid. Suspended in this fluid by means of delicate bands of fibrous tissue placed like braces on all sides, is a membranous sac also filled with fluid, which corresponds in shape exactly to the form of the vestibule, canals, and cochlea. In the walls of this sac are found the terminations of the auditory nerve.

The inner surface of the membranous sac presents a most wonder-

ful structure. Lining the sac in places are cells of various shapes, some of which bear upon their outer surface a number of minute, but sharp, stiff hairs. These cells are connected with the fibres of the auditory nerve, and it is supposed that the fine hairs described are really the extreme ends of the nerve filaments, which are thus bathed in the limpid fluid which fills the whole internal ear. Within the sac are also to be found curious little chalky particles called *otoliths*, or ear-sand.

Fig. 80. The Internal Ear.

Physiology of the Ear.—Having briefly described the structure of the ear, we will now proceed to give a concise account of its functions. The chief duty of this organ is to receive impressions of sound, and to note the differences between various sounds in force, pitch, and quality. In order to comprehend how this is done we must understand something of the nature of sound.

The Nature of Sound.—If a stone be dropped into the water, a series of circular waves extend out from the point at which the stone entered the water. These waves are caused by vibration of the water, which is produced by the motion communicated to it by the stone. In a similar manner, moving bodies communicate motion to the air. A fan, gently moved by the hand, produces waves in the air which may be felt, though not heard. The wings of a humming-bird or an insect fan the air so rapidly that waves are produced which can be recognized by the ear. This is what is termed sound. The range of sounds which can be appreciated by the human ear is very great, the lowest being produced by sixteen vibrations per second, and the highest by about forty-eight thousand vibrations per second, equivalent to a range of about eleven and one-half octaves. Persons differ in their capacity for appreciating sounds, some being able to hear lower sounds than others, and *vice versa*. It is also probable that lower animals differ from each other and from man in this respect. There is at least good reason for believing that some insects

are capable of making sounds which are produced by vibrations too rapid to be appreciated by the human ear, though they may be heard by the insects themselves. Some years ago an eminent European scientist devised an experiment by which he was able to demonstrate not only that vibrations of air much more rapid than can be detected by the human ear can be produced, but that these extremely acute vibrations possess the same qualities as those less rapid, except that they cannot be perceived by the ear.

Sounds are generally divided into musical sounds and noises, although this is a purely arbitrary division, as in reality no exact line can be drawn between these two classes of sounds. It is generally understood, however, that a musical sound is one that is produced by regular vibrations, or those which are repeated at regular intervals, while noises consist of irregular and discordant vibrations occurring at irregular intervals.

The question sometimes discussed with so much display of argument on both sides, whether there would be sound if there were no ears, we need hardly notice here; it will be at least sufficient to say that the settlement of the question wholly depends upon whether it is viewed from the standpoint of the physiologist or that of the physicist. The physiologist regards sound as the sensation produced upon the ear by certain vibrations of air; the physicist studies as sound the air-waves which produce the sensation upon the auditory nerve.

How we Hear.—The operation of hearing is a very interesting one, and becomes quite simple when the structure of the hearing apparatus is well understood, since there is provided for each necessary part of the operation an organ or series of organs well adapted to accomplish the work. When the air is set in motion by a rapidly vibrating body, the sound-waves are collected by the external ear and concentrated in the short canal at the inner end of which the drum membrane is placed. The motion of the air is communicated to the drum membrane, and by its movement the ear bones are caused to oscillate, and thus transmit the vibration to the fluid which fills the internal ear. The vibration readily extends from the fluid in the vestibule and its communicating cavities to the membranous sac which it contains, and to the limpid fluid contained in the sac. The motion of this fluid causes vibration of the delicate hairs which project into it, and which, as we have seen, are undoubtedly the ends of

the filaments of the nerve of hearing. Thus the external air-waves have been conducted to the auditory nerve, by which the impression is carried to the auditory center at the base of the brain, which in turn transmits it to the cerebrum, the seat of the intellect, and then the sound is recognized.

The Musical Instrument of the Ear.—From the peculiar structure of the cochlea it is believed that this part of the internal ear is devoted to the recognition of musical sounds, and especially to the pitch of sounds. There is in its structure so close a resemblance to the strings of a piano and the accessory apparatus that physiologists who have studied this part have universally remarked the analogy. There is even a damping arrangement, or what seems to be such, for the purpose of preventing the confusion of sounds when they are received in rapid succession. It was formerly supposed that the otoliths had something to do with the production of sound, but it is now conceded that their action, if they have any, is not known.

The Accommodation of Hearing.—Experiments concerning the action of stretched membranes with reference to sounds of various pitch have shown that the tension of the membrane must be varied for differences in pitch in order that they may be heard the best. For the safety of the ear it is also important that there should be some means of relaxing the membrane and the accessory organs so that injury shall not be received from very loud sounds. These needs are supplied by the delicate muscles of the drumhead and the *stapes.*

Use of the Eustachian Tube.—The object of this canal is to equalize the atmospheric pressure in the drum or middle ear with that outside. The pressure of the atmosphere is constantly changing, as is indicated by the changes in the barometer; hence, if no provision of this sort were made, the drum membrane would sometimes be pressed outward, and sometimes inward, which would greatly interfere with its function. This is well seen when the tube becomes closed up in consequence of a cold, which not infrequently happens; at such times the hearing is greatly obstructed. The Eustachian tube also comes into use when persons ascend to great heights by going up in a balloon or climbing mountains; also, in the cases of persons who work under water by means of diving-bells. The walls of the tube usually lie in contact, so when changes in the internal and external pressure are made rapidly it sometimes becomes necessary to

assist nature in changing the volume of air in the ears. This is readily done by a very simple means which any one can employ. After taking a deep breath close the lips tightly, and close the nostrils with the fingers by pressing them firmly together; then attempt to expel the air through the nose, as in blowing the nose, but still keep it tightly closed. By this maneuver the Eustachian tube will be opened and air forced into the drum. This procedure is found to be a very important one with divers who descend to their work under an immense bell. The weight of the water causes a very great increase in the pressure of the air in the bell upon the drum membrane. When persons so engaged neglect to observe this precaution, the membrane is not infrequently ruptured.

Source of the Power of Maintaining Equilibrium.—Careful examination of the walls of the semi-circular canals of the internal ear have shown that they do not contain fibres from the auditory nerve, and hence do not take an active part in the process of hearing. For some time it was a source of great perplexity to decide the function of these curious structures. At last an ingenious physiologist instituted a series of experiments on these organs in birds; and he found that their function is to aid in maintaining an equilibrium, by giving information respecting changes in position of the head. The manner in which this is done is very remarkable and interesting, but the process is too complicated for explanation here. It may be remarked, however, that the function is based upon the well-known fact that fluids contained in vessels have a strong tendency to retain their actual position instead of changing with every movement of the containing vessel. For instance, a glass containing water may be turned around without turning the water. The semi-circular canals contain a limpid fluid closely resembling water, and the three canals are so placed with reference to each other that the effect of any change of position may be noted by the change in the walls of the canals with reference to the fluid contained within them. This fact may explain the dizziness which often accompanies disease of the ear, the explanation being that in these cases the part of the ear is affected, the duty of which is to apprise the brain of the muscular actions necessary to maintain the equilibrium of the body.

How Direction of Sounds is Determined.—The direction of sounds is probably determined by changing the position of the head and observing the direction in which the sound is most distinctly

heard. Most lower animals can accomplish the same end in a large degree by changing the position of the ear by means of the muscles which they possess for that purpose, but which in man are not sufficiently developed to be of use.

Our power to determine the direction of sounds is quite limited, as also is the power to determine the distance from which sounds come which fall upon the ear. That is, it is very difficult, often impossible, to distinguish between a feeble sound and one which comes from a distance.

Interesting Facts about the Sense of Hearing.—Like most of the other senses, the ear refers its impression to the outside. It is a curious fact, however, that if the external ear be filled with water, this is no longer the case; sounds then seem to originate and to be located within the head.

The ear exceeds all the other senses in acuteness of perception. If impressions are made upon the eye in so rapid succession as ten in a second, they become fused; that is, they run together and become indistinguishable. In the case of the ear, however, sounds which follow one another with the rapidity of one hundred a second, as in the ticking of a fast-beating pendulum, are heard as distinct sounds.

It is a common observation that some people have not "a musical ear." This is owing to the fact that they cannot readily distinguish one tone from another. Ears which are well trained can distinguish between notes which differ less than the one-hundreth part of a tone. Notes higher than 4000 vibrations per second are, however, distinguished with great difficulty.

It is a commonly known fact that the ticking of a watch may be heard much more distinctly when held between the teeth than when at the same distance from the ear and not in contact with the teeth. Two new instruments for the relief of deafness have recently been invented which are based on this principle, known as the *audiphone* and the *dentaphone*. By the aid of these instruments the sound-waves are conducted to the internal ear through the bones of the head. It is probable that the drum membrane acts as when sounds are received in the ordinary way when present. It is said that by means of these instruments persons who were born deaf have been made to hear. These instruments have not yet been sufficiently tested to make it safe to recommend them, though they are undoubtedly useful for some cases.

THE EYE AND ITS FUNCTIONS.

The organ of vision consists essentially of two parts, the optical instrument itself, or the eye-ball, and the accessory organs and enveloping parts. The latter, which we will describe first, consist of the *orbit*, the *eyelids*, and the *lachrymal* or *tear apparatus*.

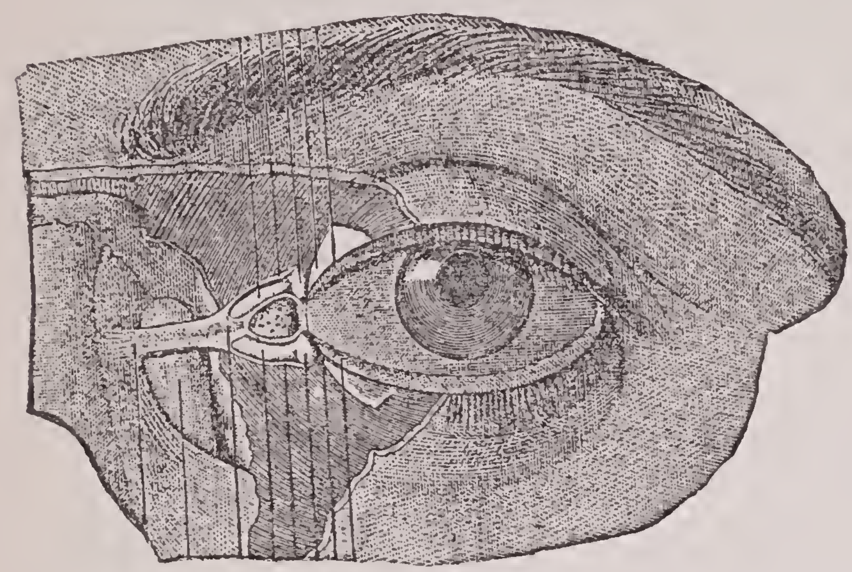


Fig. 81. The Eye, showing at its inner border the apparatus for removing the tears from the eye.

The Orbit.—In order to protect it from mechanical injury, the eye is placed in a deep socket formed by the bones of the cranium and face. The edges of the socket project so much beyond the eye-ball that it will readily escape injury, even should a blow be received upon that part of the face, unless from a small instrument aimed directly at the eye. The overhanging brow is covered with short hairs so arranged as to conduct away the perspiration when a person is sweating freely, and prevent its entering the eye. An opening in the bottom of this bony socket gives entrance to the nerve of sight, which passes into the eye-ball. In the back part of the orbit is to be found a large amount of fatty tissue, which forms a sort of cushion for the eye-ball to protect it from any injury from jar.

The Eyelids.—The eye is protected in front by two movable curtains, the eyelids, the upper of which is the larger and moves very freely, the lower being short and having little motion. The lids are chiefly composed of skin, lined with a delicate mucous membrane known as the *conjunctiva*. The edges of the lids present a row of fine hairs, the eyelashes, which protect the eye from dust, and when the lids are partially closed, diminish the amount of light that may enter the eye. Just within the row of eyelashes may be seen a line of delicate points which are the mouths of ducts leading from minute sebaceous glands which secrete an oily substance and pour it out upon the edge of the lids, by means of which they are prevented from ad-

hering together during sleep. By the same means the lachrymal fluid which lubricates the eye is prevented from overflowing upon the cheek.

The Lachrymal Apparatus.— Just within the outer and upper border of the orbit is placed a little gland, the function of which is to secrete a limpid, lubricating fluid, the *lachrymal fluid,* or tears, from which fact it is called the lachrymal gland. The fluid formed flows down and across the eye, moistening its whole anterior surface, and is drained off at the lower and internal angle of the eye by the *nasal duct,* a canal which leads to the nose. This fluid protects the eye both by washing away impurities and by keeping it transparent. When the cornea, or transparent part of the eye, becomes dry, it loses its lustre and becomes partially opaque. This is well seen in fishes when they have been removed from the water for some time. They have no lachrymal apparatus, since their natural element, the water in which they swim, answers the same purpose.

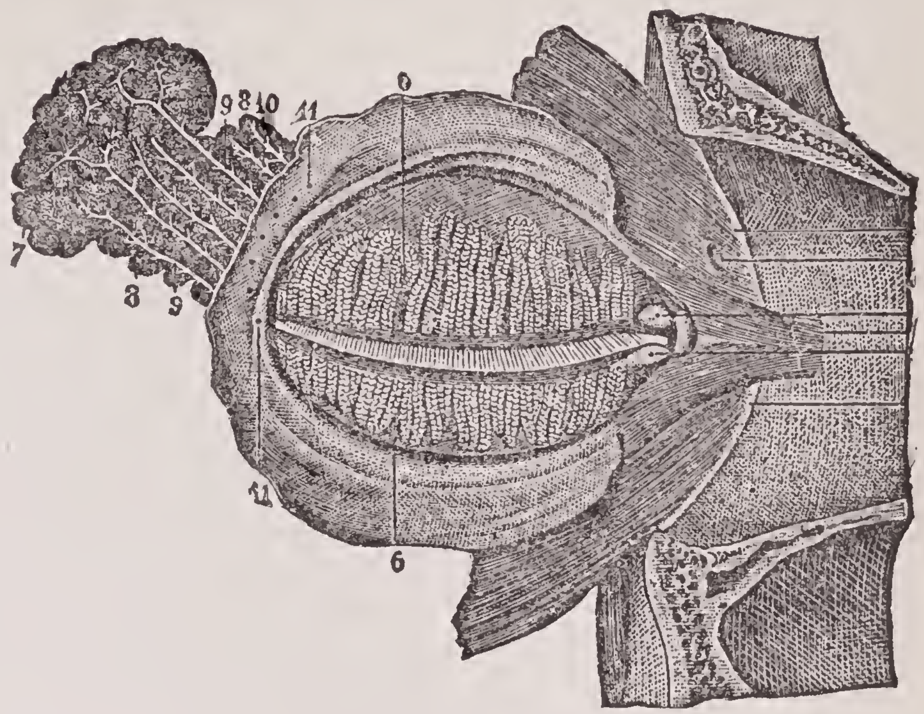


Fig. 82. The Glandular Apparatus of the Eye; 7. Lachrymal Gland. 8, 9, 10, Ducts. 11. Openings of ducts on inner border of upper lid; 6. Glands for lubricating edges of eyelids.

In the edge of each lid, at the inner end, are little openings through which the tears are drained off into the nasal duct and so conveyed to the nose. These can be seen in the lower lids by drawing them downward and forward.

The secretion of the lachrymal fluid is constant, but only in sufficient quantity for the purpose of lubricating the eye, except when the mind is laboring under the influence of some strong emotion, when it is poured out in such quantities that it escapes over the lids upon the cheek in tears. Irritating substances in the eye, a harsh, dry wind, and irritating vapors, produce the same effect.

The Eye-Ball.—The ball of the eye, which is the essential instrument of sight, in many respects resembles the camera of the photographer, as will be seen from the description. The eye-ball is not perfectly spherical in shape, though approaching the form of a globe. Its average diameter is about an inch. It is composed, essentially, of three investing membranes or coats, called *tunics,* and three transparent media inclosed, called *humors.*

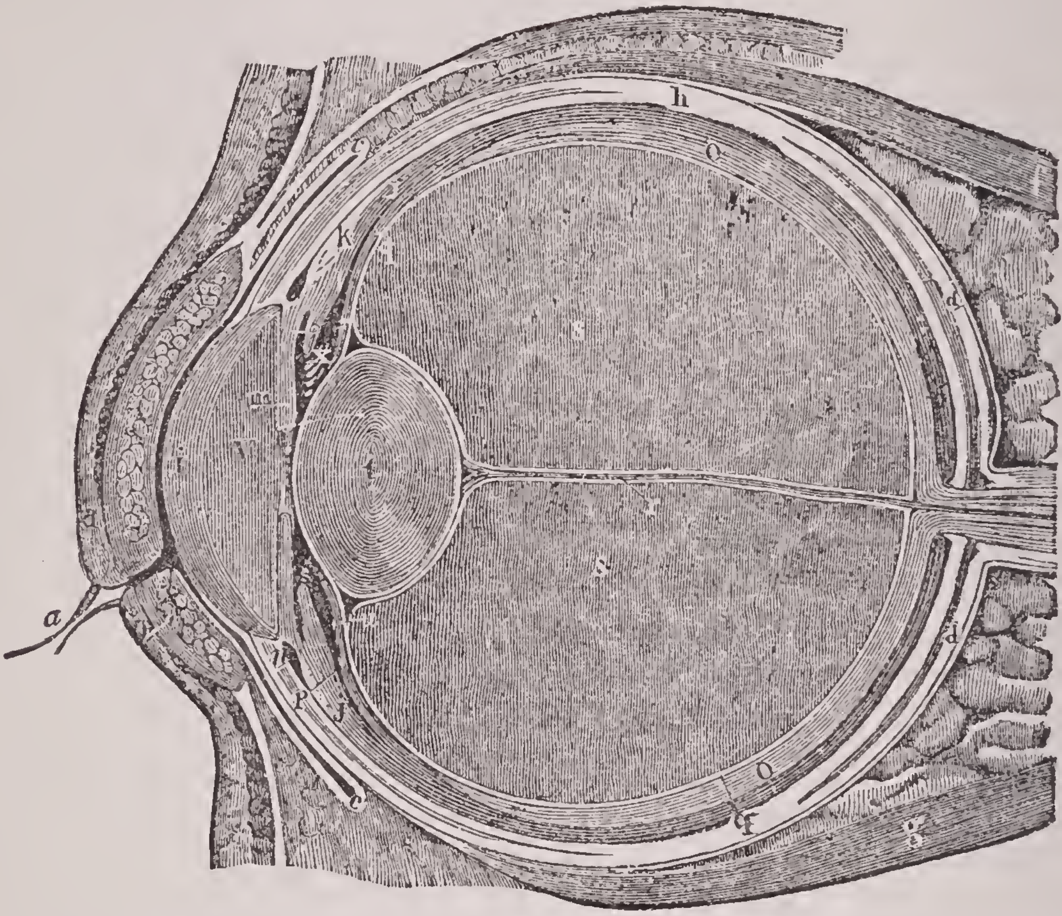


Fig. 83. Vertical Section of the Eye-Ball. *a.* Eyelashes; *d.* Eyelids; ***i.*** Cornea; *V.* Aqueous Humor; ***t.*** Crystalline Lens; *s.* Vitreous Humor; *m.* Iris; *o.* Retina.

The outermost tunic is called the *sclerotic.* It is a tough, fibrous coat, and forms what is known as the white of the eye. It covers the whole eye-ball with the exception of a small circular portion which is covered by a peculiar, horn-like, transparent structure which is a continuation of the sclerotic, and is called the *cornea.* It is this which forms the lustrous portion of the eye, through which its color is seen. The cornea acts as a window to the interior of the eye.

Within the sclerotic is another tunic, the *choroid,* which is a delicate membrane filled with blood-vessels to nourish the eye, and lined upon the inside with a layer of dark, nearly black, coloring matter. The choroid is also absent in front, ending at the margin of the cornea ; but it is continued by a circular curtain called—

The Iris.—This delicate structure is what gives to the eye its color. Its outer side is in different persons a great variety of colors, being brown, blue, gray, hazel, and many other shades. Its center is pierced by an opening called the pupil. Its back side is covered, like the choroid, with a layer of black pigment, the object of which is the same as that had in view by the manufacturer of telescopes and microscopes when he covers with a coat of black paint the inside of his instruments, viz., the absorption of wandering rays of light, and the prevention of reflection in the eye, which would occasion confusion of vision. In albinos these dark cells are wanting, in consequence of which they suffer from imperfect vision. The same is true of albinos among lower animals, as white elephants, white rabbits, etc. In blue and gray eyes the pigment cells are less abundant than in black and brown, being found only on the back side of the iris, while in black and brown eyes pigment cells are found upon both sides and in its substance. Dark eyes are usually associated with dark features on account of the general greater abundance of pigment throughout the body.

A careful examination of the iris with the microscope shows that it is made of two sets of fibres, one of which radiates from the center toward the circumference, while the other is arranged circularly. The circular fibres, by contracting, make the opening through the iris smaller, while the radiating fibres, by contracting, make it larger. Thus the size of the pupil is regulated according to the amount of light which is needed in the eye for the purposes of vision, or which may be tolerated without injury to its delicate structures. The action of the iris of the cat can be very easily seen. When exposed to a bright light, the pupil becomes very small; but when taken into a room where there is little light, it becomes greatly dilated. It is in part the great power of dilation of the pupil which enables the cat and the owl to see well where the light is insufficient for most other animals and human beings. When we enter a darkened room we cannot see distinctly for some minutes, as is also the case when we are suddenly brought into the presence of a bright light. This is owing to the fact that time is required for the iris to accommodate the size of the pupil to the amount of light furnished. When the variation in the intensity of the light is but slight, as is ordinarily the case, no perceptible time is required; but a longer period is necessary when the difference is great. Every person has experienced temporary inability to see objects distinctly after looking at the sun for a few seconds steadily.

Certain drugs possess the power to cause dilatation of the pupil by paralyzing its muscular fibres. Belladonna, one of the chief of these, derives its name, which signifies beautiful lady, from the fact that it has been much used to cause dilatation of the pupil to add brilliance to the eyes. Death has not infrequently been occasioned in this way.

The Ciliary Muscle.—Between the sclerotic and the choroid, around the edge of the cornea, is another curious little muscle, known as the *ciliary* muscle, the use of which will be seen presently.

The Retina.—This constitutes the third and inner coat of the eye. It is made up almost wholly of the end filaments of the optic nerve, which enters the ball of the eye at the back side and spreads out into a thin membrane to form the retina. It contains many delicate and curious structures connected with vision, but too complicated for explanation in a popular treatise like this. The retina is sensitive to no impressions but those produced by light. That is, if otherwise stimulated, it produces only the sensation of light.

The Crystalline Lens.—This is the middle one of the three transparent media of the eye. It is placed in the eye just behind the iris, so that the center of the pupil is just opposite its center. Its shape, as will be seen by reference to Fig. 83, is like that of a convex lens or burning-glass. It is of quite firm consistency, feeling to the touch almost as hard as cartilage. It is held in place by means of a delicate sac or capsule which incloses it and is attached by its circumference to the choroid coat just behind the iris. Its thickness is about one-fourth of an inch. The lens possesses great transparency in health, but sometimes, especially in old age, it becomes opaque, occasioning the disease known as cataract. Attached to the choroid behind the border of the capsule of the lens is the ciliary muscle previously described.

The Aqueous Humor.—This is a watery fluid contained in the small space between the lens and the cornea in front. The free inner edge of the iris floats in the aqueous humor. It is this limpid fluid which escapes when the eye is punctured by a sharp instrument.

The Vitreous Humor.—Behind the crystalline lens, and filling the greater part of the eye-ball, is the vitreous humor, so called on account of its imagined resemblance to melted glass. This structure is also very transparent. It constitutes about two-thirds of the eye-ball. The retina, the inner tunic of the eye, lies in close contact with it.

The Physiology of the Eye.—In order to understand the manner in which the mechanism of the eye operates in producing vision, we must

first learn something of the nature of light, that with which the eye has to deal. The generally accepted theory of light is what is known as the undulatory theory, which supposes that all space is filled with a subtile medium known as ether, and that light is simply the waves, or vibrations, or undulations, of this ether, just as sound is the result of the vibrations of air. These vibrations are caused by luminous bodies, as the sun and stars, and by all substances undergoing combustion.

Properties of Light.—Objects which allow waves of light to pass through them are called transparent or translucent according to the readiness with which they allow the passage of light. No substance known is perfectly transparent. Even the atmosphere and the purest water are opaque in some degree.

Light-waves travel in straight lines, radiating from their source. Those which come from a great distance vary so little in direction that they are considered as parallel.

Properties of Lenses.—Fig. 84 illustrates the property of a lens to change the direction of rays of light. The rays of light which pass from the arrow at the left of the lens have their course changed so that they cross at a point upon the right of it and form an image of the arrow inverted. This property of a lens may be readily seen by experiment with a burning-glass or a pair of convex spectacles of considerable magnifying power.

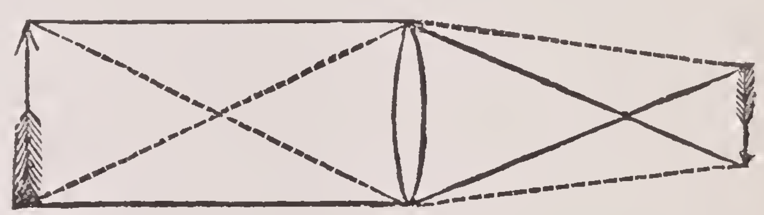


Fig. 84. Diagram showing the Optical Properties of Lenses.

How We See.—In studying the use of the eye in vision, it must be considered first as an optical instrument. As we have already seen, it contains a lens, the shape of which is similar to artificial lenses, and the effect of which in changing the direction of rays of light is precisely the same. The cornea, having a convex surface, also acts as a lens, so that there are virtually two lenses in the eye. When rays of light from an object fall upon the cornea they pass through it and on to the crystalline lens with a different direction from that in which they were received, being brought nearer together, or made to converge. Passing on to the lens they are by it made to converge still more, so that they cross just behind the lens and form an image, reduced in size and inverted, upon the retina. This may be

seen in the eye of an ox taken from the animal immediately after it is killed. By removing the outer coverings at the back part with great care, leaving the retina in place, and then placing it in such a position as to receive a strong light from some object, the object may be seen pictured upon the retina upside down.

The delicate nerve cells and filaments which form the retina convey the impressions thus made upon them to the base of the brain to the nerve center having charge of sight, whence they are communicated to the cerebrum, and the sensation of sight is produced, or the impressions recognized by the brain. Any sort of irritation of the retina or optic nerve will occasion the sensation of light, whether it be mechanical, or electrical by means of a battery.

Accommodation of the Eye.—An opera-glass, when used for viewing objects at different distances, must be adjusted in order to give distinct images of the objects viewed. If turned upon a distant object when rightly adjusted to make a near object distinct, the distant object will appear blurred and indistinct, if seen at all. Like the opera-glass, the telescope, and other similar optical instruments, the eye has an adjusting apparatus. The use of this adjusting mechanism is what is known as accommodation. By its use the healthy eye can be so adjusted as to see with the greatest possible degree of distinctness objects at the extreme limits of vision, as well as objects very near to the eye. This power differs with different persons in accuracy and in the extent of its limits. A near-sighted person has a very small range of accommodating power, that is, he can see clearly only objects which are within narrow limits of distance.

A very simple experiment will make clear to all what is meant by accommodation. Place in a strip of wood two or three feet long, two pins in range with each other, one at either end of the strip. Now hold the strip out horizontally at about the level of the eye, with one end toward the eye. By this arrangement one of the pins will be two or three feet farther from the eye than the other. Now look at the pin nearest the eye. While doing so it will be observed that an indistinct view is also obtained of the pin at the other end, and that it looks blurred. Then look sharp at the pin at the farther end. The pin nearest the eye will now appear blurred and indistinct. This is because the eye cannot accommodate itself to more than one distance at a time. Another interesting experiment shows the same thing in a different way. Make in a card-board two small holes about the dis-

tance apart shown in Fig. 85, in horizontal line with each other. Place the card very near to the eye, and hold vertically in the fingers a needle at a distance of eight or ten inches from the eye. When the eye is fixed intently upon the needle, it is seen clearly; but if the attention be directed to an object either farther away or nearer by than the needle, it will appear indistinct and also double. If moved near enough to the eye, it will appear double continually. The nearest point at which it appears single is the near limit of accommodation.

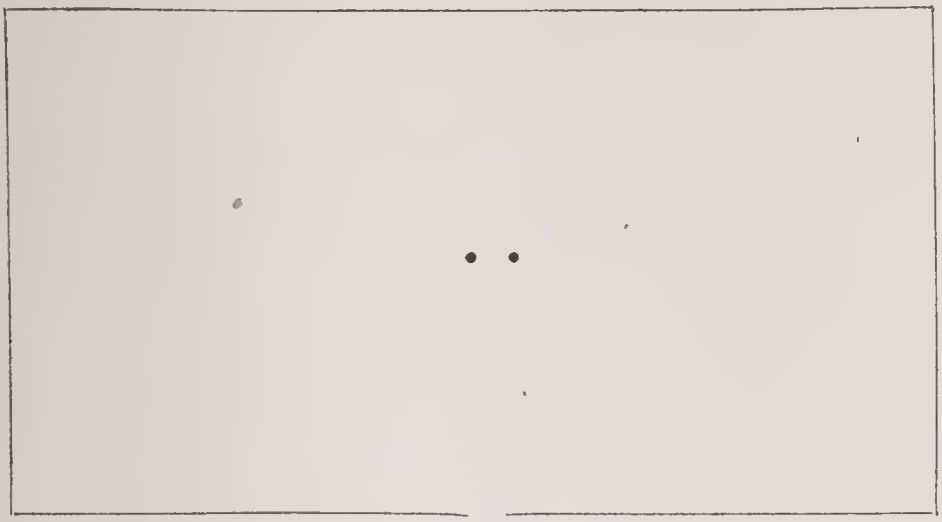


Fig. 85.

Accommodation is accomplished by the action of the ciliary muscle, by means of which the form of the lens, and hence its refracting power, is changed, as shown in Fig. 86.

Visual Judgments.—With the exception of the auditory sense and the sense of sight, all others of the senses require for their excitation the actual contact of something. No other sense gives us so much and such varied information respecting external things as the eye; yet a careful study of the knowledge thus gained shows us that the eye is very greatly aided by the other senses. Indeed, with only the sense of sight, we should be very badly off indeed, and the function of sight would render us but little service. In making visual judgments, or forming opinions which seem to be

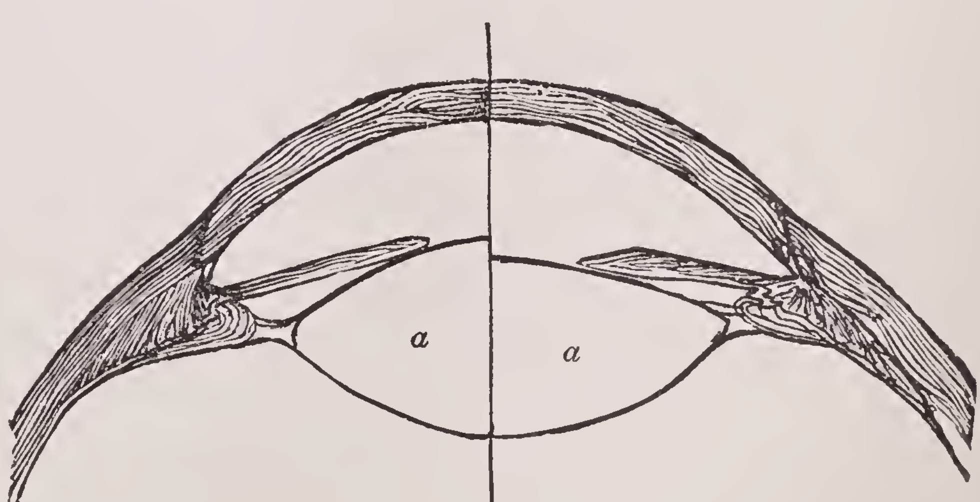


Fig. 86. At the right of the vertical line, the lens, *a a*, is shown flattened, as when adjusted for seeing at a distance; on the left, the lens is thickened, as in near-sighted persons and when examining near objects.

based upon the impressions received through the eye, we never take into account our dependence upon other senses, because we are scarcely able to separate them under ordinary circumstances.

Judgment of Distance and Size.—The power to judge of distance is evidently acquired. The little child reaches out its hand for the moon, undoubtedly supposing it to be within easy reach. A landsman at sea for the first time can form no correct estimate of distance. The same is true of a person accustomed to live in a hilly or mountainous section when he first visits a prairie country. The judgment of distance is formed partly by the combined use of the two eyes,—one serving as a means of correcting the other,—by the amount of muscular effort required to accommodate the eye to see the objects clearly, and by the relative size of objects with which we are familiar. For instance, we are familiar with the size of a man or a horse; if we see a man or a horse some distance away, we judge something of the distance by the apparent size. If we were to look through a reversed telescope, which makes everything look small, we should have the same impression, that of a person a long distance off, even though he might be very close by. The advantage of using both eyes in judging of distance is well appreciated by one who attempts to thread a needle with one eye closed.

We are aided in judging of the size of an object by a knowledge of its distance. We can form no notion of the size of the moon, because we can form no visual estimate of its distance, and *vice versa.*

Judgment of Solidity.—We are enabled to form an opinion respecting the solidity of an object by two means; first, by means of the lights and shades of its surface, and second, by the conjoined use of the two eyes, which enable us to see more than half of a sphere, owing to the difference in position of the two eyes.

It is thus evident that we do not form opinions respecting objects exactly as we see them, but as the impressions of sight are corrected by comparison with each other and with the impressions received through the other senses.

Curious Facts about the Sense of Sight.—There are many curious facts about sight well worth mentioning, only a few of which we have room to consider. First we may mention that although every one is familiar with the fact that color as well as simple light may be appreciated by the eye, no explanation has yet been found for the power to distinguish color. The color of objects is due to the fact

that light is compound, and that some objects have the power to absorb some portions of the constituent elements of light and reflect others, the elements reflected determining the color. For example, an object reflecting red rays only, is red; one reflecting blue only, is blue, etc. It was formerly supposed that red, yellow, and blue were the primary colors, or color sensations; but an eminent scientist has recently shown that the old view is incorrect, and that the primary color sensations are red, green, and violet. When all three of these colors fall upon the retina at once, white or colorless light is produced. By their combination in various proportions all other color sensations may be produced. White may also be produced by combining the following colors: red and blue-green; orange and blue; yellow and indigo-blue; green-yellow and violet; purple and green.

After-Images.—After looking at a bright object, as the sun, for a few seconds, and then closing the eyes, the image formed on the retina will persist for some time. The same phenomenon may be noticed in the morning when the retina is rested. If upon first waking a person looks at the window, he may, upon closing his eyes, still retain the image with all the distinctness with which the objects viewed were seen when the eyes were open, the same form, color, and other visual properties being accurately preserved. Such images as these are known as positive after-images. A more usual form of after-image is that which is produced by looking upon a white ground after the eye has been for some time steadfastly fixed upon some dark or colored object. If a person has been looking at a white spot upon a dark ground, upon looking at a white ground, as the wall, he will see a dark spot of the same size and form as the light spot. When the spot is of a red color, the image seen on the white ground will be greenish-blue, which is the complement of red. Orange produces blue; green, pink; yellow, blue; etc. The explanation is that the part of the retina upon which the image of the object is formed becomes weary with receiving the particular sensation, and consequently while the rest of the retina which is fresh receives a sensation corresponding to the color of the object viewed, the tired spot responds to but a part of the rays, and so shows a different color, really making a physiological decomposition of the rays of light. Images of this sort are called negative.

The Blind Spot.—The portion of the retina which possesses most acute vision is the visual center, which is a little to one side of the point at which the optic nerve enters the eye. The point of entrance of the

optic nerve is wholly insensitive to visual impressions, as there are at this point none of the terminal elements of the optic nerve, which alone possess the power of receiving impressions. The existence of this insensitive portion of the retina, commonly termed "the blind spot," can be easily shown by a simple experiment with Fig. 87. Holding the book

Fig. 87.

squarely before the face and so that the figure will be on a level with the eyes, place the hand over the left eye, and with the right eye look steadily at the small cross at the left end of the figure. Now place the book at a distance of about four inches from the eye. Both the cross and the round white spot will be distinctly visible; but as the book is moved from the face the white spot will disappear at a distance of six to eight inches. With a little care any one can perform the experiment. Another way of showing the same fact without the figure is this: Pin two cards upon the wall about two feet apart, and on a level with the eyes. Now close the left eye and look at the left card with the right eye, or *vice versa*. Both cards will be visible, the right one indistinctly, of course. Keeping the right eye fixed upon the left card, walk backward. At a distance of six to eight feet from the cards the right one will vanish.

Contrast.—A white stripe placed between two black stripes looks much whiter at its edges than in the middle, which may even look a little dull in contrast with the edges, though the color is uniform. A small sheet of gray paper placed in the middle of a larger sheet of green paper and covered with a sheet of thin tissue paper, appears of a pink color, which is complementary to green.

HYGIENE OF THE SPECIAL SENSES.

The Law of Use and Abuse.—Sensation is due to change of state. If the external agents which make impressions upon our organs of sense remained always in the same relation to them, we should possess sensibility or sensation but a very brief space of time. Our sensations arise from the constant changes in the relations of surrounding objects to our organs of sense. For example, an object laid upon the hand resting upon a table is at first appreciated by the sense of weight or pressure. The first moment of contact the most intense sensation is experienced; after this the impression gradually diminishes, until finally the object is no longer felt at all unless the hand is moved. If the hand be placed in water which the sense of temperature at first appreciates as warm, it very soon loses the sensation of contact with water altogether unless the hand is stirred. Flavors at first very marked, when the sapid substance is held some time in the mouth become less intense. The most sensitive nose may become so accustomed to foul odors that it can no longer appreciate them. This is experienced by every person who leaves a close room for a few minutes and walks in the pure air. Upon returning, the close, fusty air is almost intolerable; but in a few minutes it is no longer noticed. Loud sounds are no longer heard by ears constantly accustomed to them unless they are varied, or the attention is especially called to them. An object continually gazed at finally disappears from view.

Thus all sensation depends upon constant change of state. From this fact we may deduce the general law relating alike to all the senses, that frequent change is essential. Too long use of any of the senses in any particular way should be avoided, as by this means their sensibility is blunted.

Evils of Excessive Stimulation of the Senses.—Excessive stimulation of any sense is felt as pain, when extreme in degree. A sensation of warmth is pleasurable, but neither extreme cold nor extreme heat is felt as intense heat or cold, but as pain. Very loud sounds, as the noise of an explosion, are avoided as painful to the ear. Moderate light is grateful to the eye, but an intense light, as that of the sun, causes pain. Pain is a faithful sentinel of danger; and so, as might be supposed, these intense stimulations of the nerves of sense are harmful, and should always be avoided when possible. When experienced, they

rapidly deteriorate the sensitiveness of the organ involved. A tongue accustomed to the strong flavors of highly seasoned food, ceases to appreciate the delicate flavors which naturally pertain to most articles of diet in a less artificial condition. Hence the evil of condiments. Smoking, tobacco-chewing, tea-tasting, and the excessive use of tea and coffee, as well as the use of strong alcoholic liquors, deteriorate and often almost wholly obliterate the sense of taste.

The sense of smell is often entirely lost in consequence of the vile habit of snuff-taking. The habit sometimes acquired by smokers, of expelling tobacco smoke through the nose, ruins the delicate sense of smell. The nerves of this sense, being more slightly protected than any other, are very easily injured. Nasal catarrh also obliterates the sense of smell in many cases.

When we consider the great importance of most of the special senses, and the great value of all, it is indeed surprising that so little pains is taken to preserve them. Too often their value is not appreciated until they have been ruthlessly squandered by careless habits, and are in many cases irrecoverable. On account of their great importance, we shall devote a little space to the special consideration of the senses of sight and hearing.

HYGIENE OF THE EYE.

Being one of the most delicate of all the organs of sense, the eye is exceedingly liable to injury by improper use or exposure. Dr. Edward G. Loring, an eminent oculist of New York City, makes the following excellent remarks on this subject :—

Common Neglect of the Eye.—"Whatever an ounce of prevention may be to other members of the body, it certainly is worth many pounds of cure to the eye. Like a chronometer watch, this delicate organ will stand almost any amount of use, but when once thrown off its balance, it can very rarely be brought back to its original perfection of action, or, if it is, it becomes ever after liable to a return of disability of function or the seat of actual disease. One would have supposed from this fact, and from the fact that modern civilization has imposed upon the eye an ever-increasing amount of strain, both as to the actual quantity of work done and the constantly increasing brilliancy and duration of the illumination under which it is performed, that the greatest pains would have been exercised in maintaining the organ in a condition of health, and the greatest care and

solicitude used in its treatment when diseased. And yet it is safe to say that there is no other organ in the body the welfare of which is so persistently neglected as the eye.

"I have known fond and doting mothers to take their children of four or five years of age to have their first teeth filled, instead of having them extracted, so that the jaw might not suffer in its due development, and become in later years contracted; while the eye, the most intellectual, the most apprehensive, and the most discriminating of all our organs, receives not even a passing thought, much less an examination. It never seems to occur to the parents that the principal agent in a child's education is the eye; that through it it gains not only its sense of the methods and ways of existence of others, but even the means for the maintenance of its own; nor does it occur to the parents for an instant that many of the mental as well as bodily attributes of a growing child are fashioned, even if they are not created, by the condition of the eye alone.

"A child is put to school without the slightest inquiry on the part of the parent, and much less on the part of a teacher, whether it sees objects sharply and well defined, or indistinctly and distorted; whether it be near-sighted or far-sighted; whether it sees with one or two eyes; or finally, if it does see clearly and distinctly, whether it is not using a quantity of nervous force sufficient after a time not only to exhaust the energy of the visual organ, but of the nervous system at large."

Tobacco a Cause of Eye Disease.—The numerous observations on the subject leave no room to doubt that the use of tobacco is a potent cause of disease of the eye. In fact, instances of nearly every functional disease of the eye have been traced to the use of this powerful poison. Amaurosis, and total blindness from degeneration of the optic nerve, have also been traced to this cause. Recent observations point to tobacco and alcohol as the great causes of color-blindness, or Daltonism, which accounts for the fact that it is very much more common in men than in women.

Effects of Poor Light.—The use of poor light, and especially the improper construction of school-rooms in relation to light, is a most potent cause of diseases of the eye. Careful examinations of large numbers of students in all grades have shown that defects of sight increase in a rapid ratio from the lowest grades to the highest, students in the higher classes in colleges and universities suffering to a most astonishing and alarming extent.

Attention should be given to the eyesight of children at an early age, and especially before they are sent to school, or before a profession or trade is chosen for them. If the sight is found to be weak or otherwise defective, they should not be compelled to close confinement with books, and should be put to learn some trade or engage in some business which will not require close attention of the eye. An eminent New York oculist has recently urged the enactment of a law requiring that all children be submitted to an examination of the eyes before being granted admission to the public schools. If this plan should be adopted, no doubt many cases of disease of the eye which become serious by neglect, might be cured by the early discovery which would be thus made.

A Cause of Near-Sightedness.—One of the recognized causes of near-sightedness is looking at near objects for too long a time without relieving the eye. The optical apparatus is, by a curious mechanism provided by nature, constantly adapted to the varying distances at which objects are viewed when the eyes are being employed in looking about at various objects. If near objects are looked at too long a time, the result will be that the particular adjustment for short distances will become a more or less permanent condition. It is in this way that watch-makers, microscopists, proof-readers, compositors, writers, book-keepers, and especially students, are so liable to this disease of the eye. It should be recognized that a near-sighted eye is really a diseased eye. The idea held by many persons that an eye which has this peculiarity is an uncommonly strong one is an error. Short-sight is an evidence of weakness and disease rather than of strength.

The following very sensible remarks referring to the prevention of this defect in school-children we quote from the *Educational Weekly*:—

"Encourage the pupil to look off the book frequently, to change the focus of sight by regarding some distant object. It is not enough to look around vaguely; the eye must be directed to something which is to be clearly seen, like a picture or a motto upon the wall, or a bit of decoration. The greatest damage to the eyes of students is the protracted effort to focus the printed page. It was simply barbarous, the way we used to be "waked" in school, when we looked off the book. It is easy for a teacher to know the difference between the resting of the eye and the idle gazing around that cannot be allowed.

I regard this as most important, and the disregard of it as most prolific of trouble."

The following excellent rules for preserving the health of the eyes have been chiefly compiled from the best authorities on the subject:—

1. Never use the eyes when they are tired or painful, nor with an insufficient or a dazzling light. Lamps should be shaded.

2. The light should fall upon the object viewed from over the left shoulder, if possible; it should never come from in front.

3. The room should be moderately cool, and the feet should be warm. There should be nothing tight about the neck.

4. Hold the object squarely before the eyes, and at just the proper distance. Holding it too near produces near-sightedness. Fifteen inches is the usual distance.

5. Never read on the cars, when riding in a wagon or street-car, nor when lying down. Serious disease is produced by these practices.

6. Do not use the eyes for any delicate work, reading, or writing, by lamp-light, before breakfast.

7. Avoid much use of the eyes in reading when just recovering from illness.

8. Never play tricks with the eyes, as squinting or rolling them.

9. If the eyes are near-sighted or far-sighted, procure proper glasses at once. If common print must be held nearer than fifteen inches to the eye for distinct vision, the person is near-sighted. If it is required to be held two or three feet from the eye for clear sight, the person is far-sighted.

10. A near-sighted person should not read with the glasses which enable him to see distant objects clearly. A person who has long sight should not attempt to see at a distance with the glasses which enable him to read.

11. Colored glasses (blue are the best) may be worn when the eye is pained by snow or sunlight, or by a dazzling fire or lamp light. Avoid their continued use.

12. Never patronize traveling venders of spectacles.

13. Rest the eyes at short intervals when severely taxing them, exercising the lungs vigorously at the same time. Tired eyes may often be refreshed by bathing in cool water, or water as hot as can be borne.

14. Avoid sudden exposure of the eye to a bright light, as when first waking from sleep. Study by lamp-light before breakfast is particularly injurious on this account.

15. Defective ventilation, unequal heating,—causing cold feet and congestion of the head,—and bad food, causing impure and impoverished blood, are serious causes of diseases of the eye.

16. Popular eye-washes, and various ointments, salves, etc., prepared according to popular recipes, or sold by quacks, should never be used.

17. Upon the discovery of any defect in the sight, consult a competent physician (not a traveling quack) at once, as serious disease may be saved by timely advice or treatment.

HYGIENE OF THE EARS.

The number of people who suffer with defects of hearing in greater or less degree is almost if not quite as great as those who suffer with defective eyesight. The ears are neglected as much as the eyes; but, fortunately, slight impairment of hearing is not accompanied by anything like so great inconvenience or loss as an equal degree of impairment of vision. From inattention, neglect, and abuse, the ears become seriously or hopelessly diseased, when a little timely attention or warning might have saved them. It should be mentioned in this connection that diseases of the ear are to be avoided not only on their own account, but on account of the fact that owing to the close proximity of the organ to the brain, and its intimate connection with the bones of the skull, serious and even fatal disease not infrequently results from affections of this organ. We will call attention to some of the most important points connected with the hygiene of the ear.

Danger of Meddling with the Ears.—The common habit of picking at the ears to remove the wax or cerumen which accumulates in them, is very injurious. Especially bad is the use of ear-picks or spoons. Boring out the ear with the twisted corner of a towel is a most absurd as well as injurious practice, since it not only does not remove more than a very small portion of wax, but crowds the balance down into the bottom of the canal, against the delicate membrane of the drum. Except in cases of disease, ear-wax seldom requires removal, as nature has provided for this. When the ears are let alone, as they should be, the wax dries and scales off in thin flakes, which drop from the ear spontaneously. It is only in cases of disease that the wax accumulates to such an extent as to be detrimental. If there is itching of the ears, it is a sign of disease; and the more they are irritated by picking or cleaning, the worse the evil will become. The more assiduous the attempts to keep the ears free from wax, the greater will be the accumulation, as

the secretion is increased by the mechanical irritation. Well-meaning mothers often do their children a great amount of harm by attempts to keep their ears free from what nature designed as a protection. The protest which children always make to having their ears bored out with towels and scrubbed with soap and water inside as well as outside, is a perfectly natural and entirely proper resentment of the outrage. The outer parts of the ear may very properly be washed as often as desired, provided they are always wiped dry; but nothing should ever be introduced into the canal of the ear unless made necessary by disease or accident.

Putting things in the ear is a practice sometimes acquired by children, and often irreparable injury is thereby done. Children should be carefully watched, and early taught to let the ear alone. Beans, kernels of rice, wheat, and corn, and a great variety of small objects, have been removed from the ears of children by surgeons to whom they have been taken for treatment for deafness. Inflammation is not infrequently set up by this means, which may occasion permanent loss of hearing. Throwing at each other wheat, sand, and other small objects, should be strictly forbidden children, and should never be practiced by any one. We recently met a gentleman whose hearing in one ear was wholly destroyed when a child by having lodged in his ear a kernel of wheat from a handful thrown at him by a playmate. It was never extracted, and the inflammation excited caused a permanent loss of hearing.

Danger of Boxing the Ears.—The common practice of cuffing the ears is not only cruel but dangerous. The violent forcing of air into the ear in this manner has often caused rupture of the delicate drum membrane. Sometimes serious inflammation is occasioned; and in one case which we have in mind a child died from the effects of a cuff upon the ear received at school. Both parents and teachers often box or cuff the ears of children for inattention, when it will be found in a large number of cases in which a child is apparently inattentive that the difficulty is hardness of hearing, which will of course be made worse instead of being remedied by the punishment inflicted. It should be understood and remembered that the hearing of children is often temporarily impaired by various causes, particularly by colds and attacks of "earache," and also that in some forms of deafness a person may be quite hard of hearing when not expecting to be spoken to and hence not giving attention, and yet hear very well when listening. Before a child who seems to be habitually inattentive is punished for the supposed fault, his

ears should both be carefully tested by trying each one alone with a watch, or by speaking in a moderate tone of voice at different distances.

Taking Cold in the Ears.—The form of ear disease known as throat deafness is that in which the impairment of hearing is really due to disease of the throat, which is most commonly caused by taking cold. The thickness of hearing due to a common cold in the head is occasioned by the thickening of the mucous membrane about the openings of the Eustachian tubes in the throat. This usually passes away in a short time; but in cases of catarrh, especially post-nasal and pharyngeal catarrh, the condition may become permanent; and the local disease may extend up into the canal and even to the ear itself, occasioning very great injury to the ear.

It ought to be generally known, too, that the very common affection called earache is really a matter of quite serious character, being inflammation of the middle ear, or drum of the ear. Treatment should be prompt, and care should be taken to prevent recurrences, as the hearing may be thereby permanently injured. Full directions for treatment are given in the proper place.

Exposures of the Ears.—Both extremes should be avoided in the case of the ears. Too much protection makes them delicate and easily disturbed by the occasional exposures to which they must be subjected. It is probably for this reason that women are more liable than men to suffer with acute inflammation of the ear, as has been observed by some aurists. People who always have their ears covered or protected by plugs of cotton, are quite sure to be always troubled with their ears. The ears should be accustomed to exposure, and only protected when subjected to some unusual exposure, as when riding a long distance in a cold wind. The use of cotton in the ears is attended by some risk, being often productive of harm, as cotton placed in the ear is not infrequently forgotten, being left in place, and even pushed farther into the ear by successive plugs. As many as three pellets of cotton which had been successively inserted in this way have been removed by an aural surgeon. When thus retained, wax accumulates about the cotton, and thus may occasion mechanical obstruction to hearing, and serious inflammation.

Cold water should never be introduced into the ear. When injected with a syringe, and even when poured in, it causes giddiness, and may give rise to inflammation. Boys often cause an inflammation of the ear by "going in swimming" or ducking the head in wa-

ter. By submergence of the head the external canals are filled with water, which is usually of a temperature lower than that of the blood, which causes congestion and may occasion inflammation. Early deafness is often produced in this way. Those who own dogs which are accustomed to go into the water much, or are often thrown in, frequently find that they become deaf in consequence.

Wetting of the hair is a cause of injury to the ear, as well as wetting the ear itself. The practice is especially harmful in cold weather. Care should be taken to dry the hair, especially near the ears, whenever it is wet.

It is well to protect the ear from loud sounds, which are especially liable to cause injury if unexpected. When anticipated, the drum membrane is prepared by the action of muscles for the purpose, so that injury is less likely to occur. Persons have been made stone deaf by confinement in a belfry during the ringing of a large bell. Artillery-men often lose their hearing in consequence of the loud noises to which their vocation exposes their ears. Even shouting loudly in the ear has been known to produce injury. A bit of cotton placed in the ear will do much to deaden sound.

One other caution should be given in conclusion. The attempt is sometimes made to relieve toothache by placing in the ear cotton saturated with camphor, chloroform, or other medicaments. While this mode of treatment is sometimes successful, the plan is not a good one nevertheless, as the injury done to the ear may be greater than the benefit received by the tooth. Both the tooth and the ear should be treated on their own merits, each for its own maladies, unless the other be implicated as a cause.

Full explanations respecting the use of ear-trumpets and other means of aiding impaired hearing are given in connection with the consideration of the subject of deafness.

THE CIRCULATORY APPARATUS.

The organs of circulation, or the circulatory apparatus, constitute the means by which the blood, the nutritive fluid of the body, is circulated through all its different parts, carrying new material to parts requiring it for repairs, and carrying away to be expelled from the body worn-out and useless or clogging elements wherever found. The circulatory apparatus consists of the *heart*, the *blood-vessels*, and the *lymphatics*, the structure and functions of which we will now briefly examine.

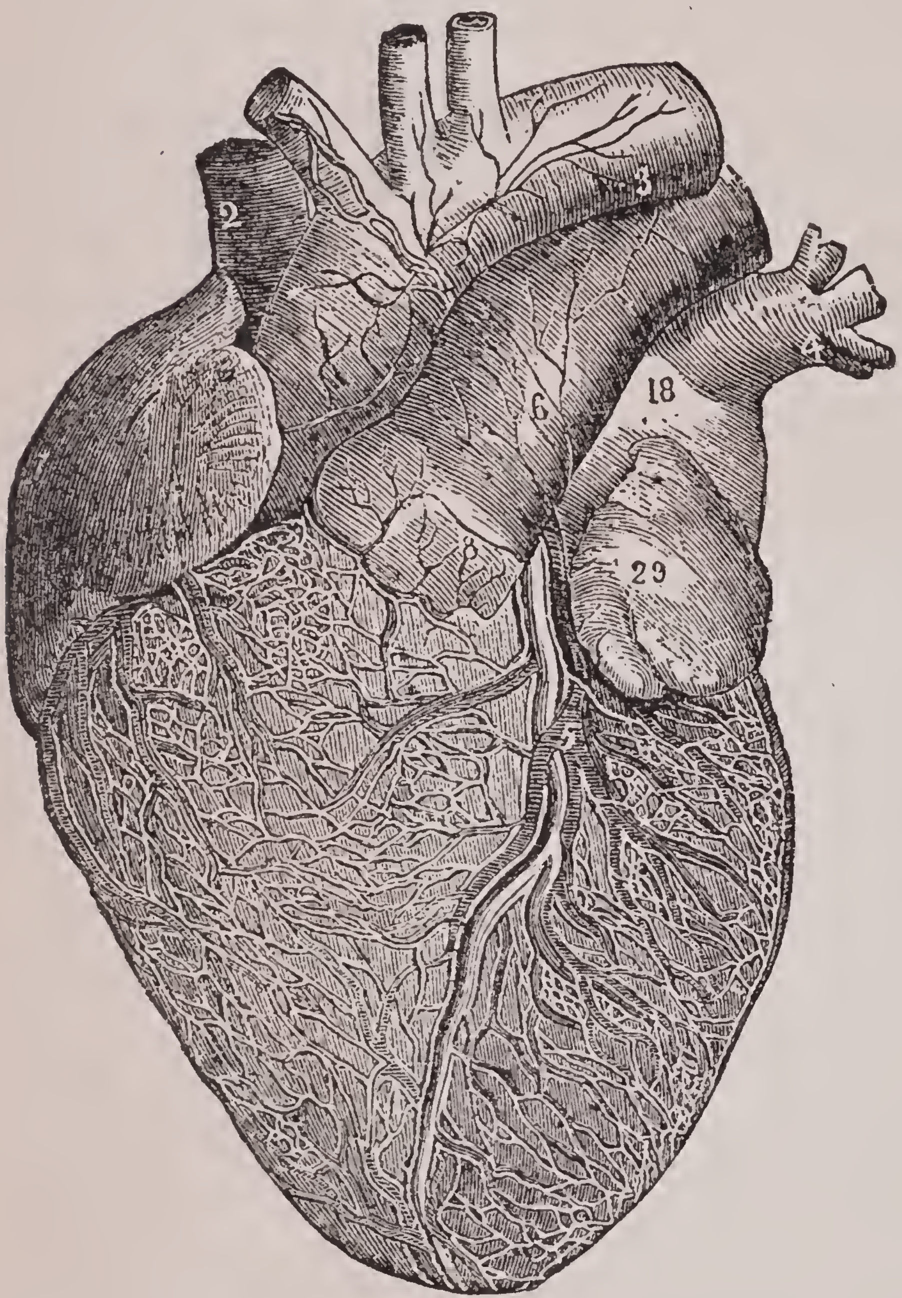


Fig. 88. The Heart. 1. Right Auricle; 18. Left Auricle; 2. Vena Cava; 3. Aorta; 4. Pulmonary Veins; 5. Coronary Artery and Veins; 6. Pulmonary Artery.

The Heart.—Fig. 88. The heart is the central organ of the circulation, and hence is very properly placed near the center of the body, in the thorax, its exact position being a little to the left of the median line in the central part of the chest, between the two lungs. The heart is a muscular organ. It is, in fact, a hollow muscle. It is conical in shape, and is suspended in the chest, with the base upward and the apex downward. The apex is free, and when the heart is beating may be felt to strike the chest just below the fifth rib

and about one and one-half inches to the left of the breast-bone. The weight of the heart is ten to twelve ounces in men, and eight to ten in women. The heart is really a double organ, and may properly be considered as two hearts joined together. See Fig. 89. In some lower animals the two hearts are separate. See Fig. 90. The two hearts are called, respectively, the right heart and the left heart. Each heart has two cavities, a lower, called the *ventricle,* and an upper, called the *auricle,* on account of its ear-like appearance.

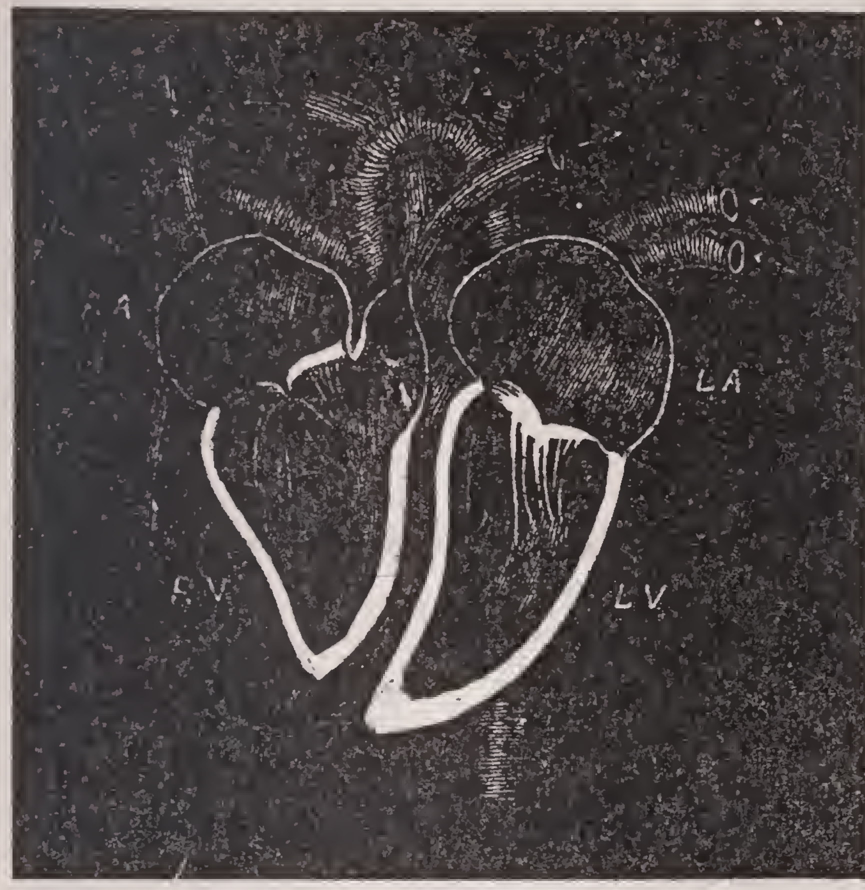


Fig. 89. Diagram showing the two sides of the Heart and their cavities.

The walls of the left ventricle, or the lower cavity of the left heart, are very much thicker than those of the right ventricle. A diagram of the cavities is shown in Fig. 89.

Valves of the Heart.—The auricle and the ventricle of each heart communicate with each other, but there is no direct communication between the two hearts except in the infant before and just after birth when there is an opening between the two auricles. This opening between the auricle and ventricle in each heart is guarded by a valve which allows the blood to pass from the auricle into the ventricle but not back into the auricle. The valve in the left heart is called the *mitral* or *bi-cuspid,* having two cusps, or curtains. The valve in the right heart, having three cusps, is called the *tri-cuspid* valve. See Fig. 91.

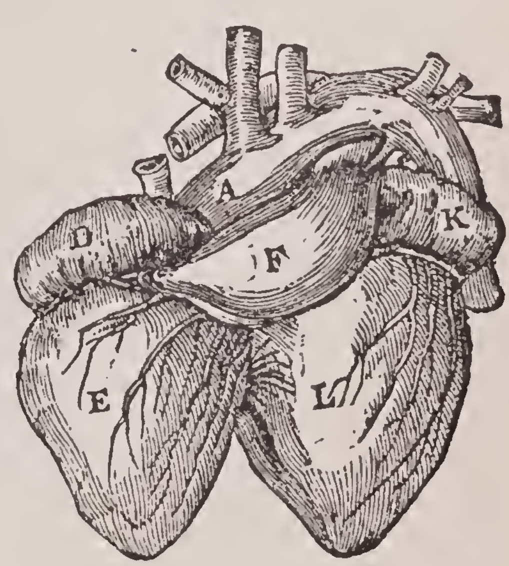


Fig. 90. The Double Heart of the Dugong.

Each of the cavities of the two hearts communicates with blood-vessels, the auricles communicating with

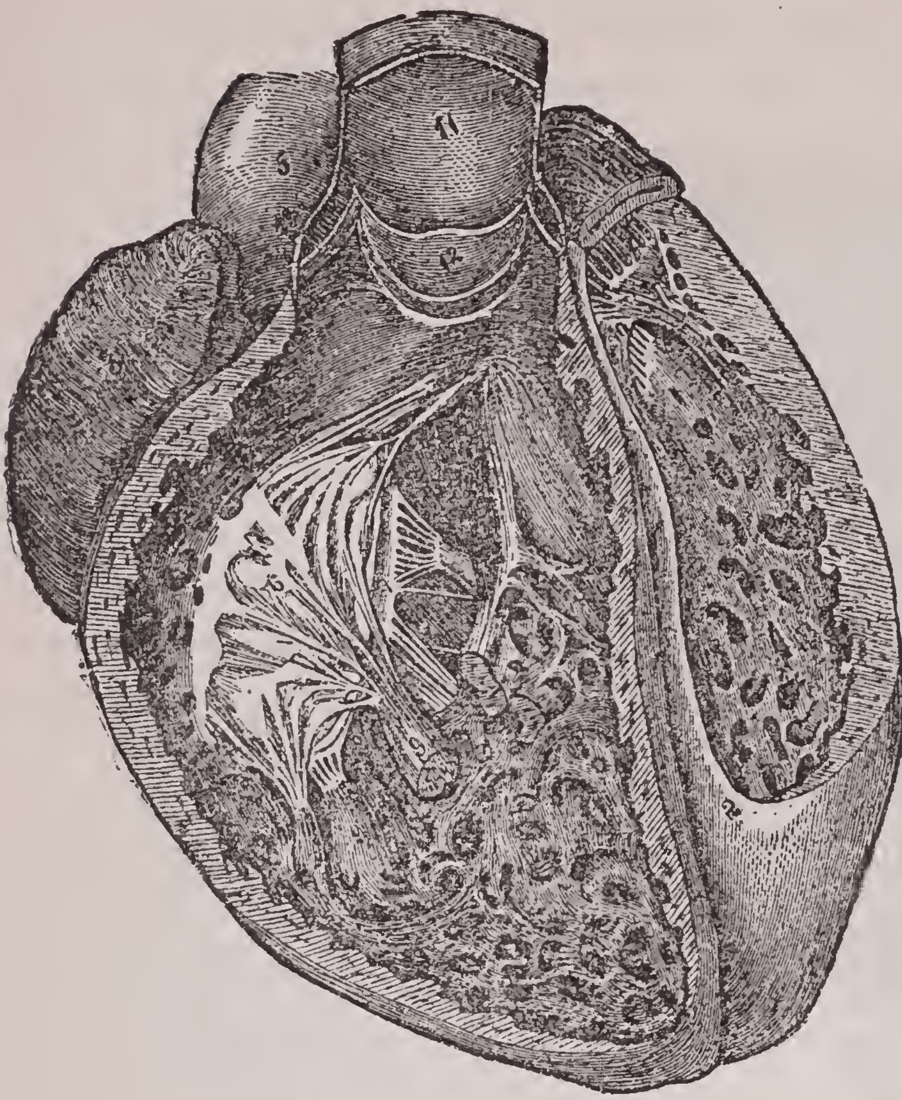


Fig. 91. The Heart with portions of its walls removed, showing interior of cavities. 6. Tri Cuspid Valve; 10. Mitral Valve; 12. Semi-Lunar Valve.

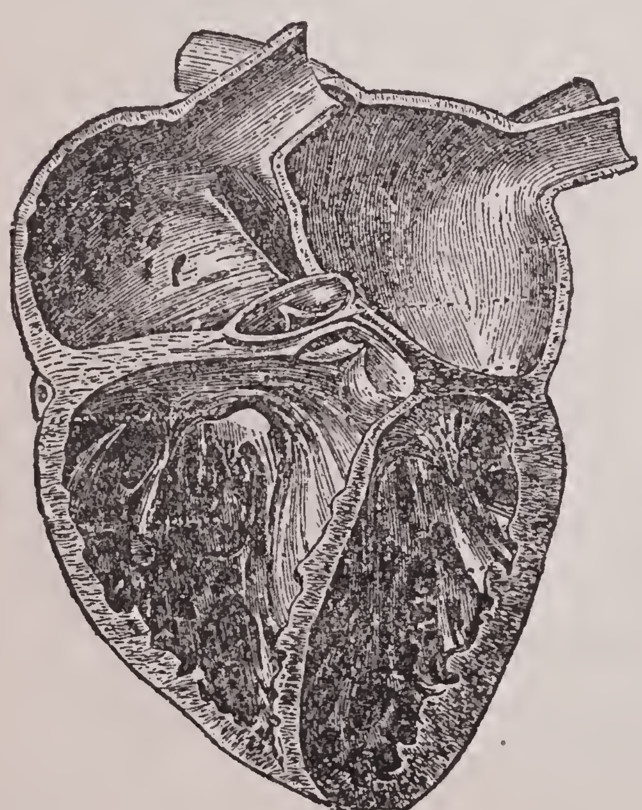


Fig. 92. Section of the Heart, showing relative size of its cavities, and thickness of the walls of the ventricles.

veins, and the ventricles with arteries. The openings between the ventricles and arteries are also guarded with valves upon both sides, which from their half-moon shape are termed *semi-lunar* valves. The left semi-lunar valve guards the opening between the left ventricle and the *aorta.* The right semi-lunar valve guards the opening between the right ventricle and the *pulmonary artery.* The veins have no true valves at their openings into the auricles, but are slightly constricted.

The Pericardium.—The heart is contained in a delicate sac called the heart-case, or *pericardium,* the lining membrane of which secretes a fine lubricating fluid to secure the utmost ease of action. The heart is lined with a delicate membrane, the *endocardium,* which is continuous with the lining of the blood-vessels.

The Blood-Vessels.—There are three classes of blood-vessels,—arteries, capillaries, and veins. The arteries differ from the veins in having rigid walls.

which are in the large arteries chiefly composed of connective tissue, but in the smaller ones contain a large proportion of involuntary muscular tissue. The smallest arteries, called arterioles, have their walls almost wholly made up of muscular tissue. The arteries derive their name from the fact that they are found empty after death, which led the ancients to suppose they were simply ducts for air. Fig. 93 gives a general view of the arterial system.

Fig. 93. The Arterial System.

Names of Some of the Principal Arteries.—The following are the names of some of the principal arteries of the body :—

The *aorta* is the great artery of the body. It starts at the left ventricle, and subdivides into numerous branches in the various parts of the body through which it passes. Arching upward as it leaves the heart, the aorta sends off large branches which supply blood to the head and upper extremities. The chief of these are the *innominate,* the *carotid,* and the *subclavian.* The first two supply the right arm and the head, and the third the left arm. In the arms the arteries become first the *brachial,* which divides in the fore-arm into the *ulna* and *radial,* the ends of which unite in the hand to form an arch in the palm, known as the *palmar arch.*

As it passes downward through the chest, the aorta gives off branches to the lungs and other organs contained in the thorax. In the abdominal cavity, branches are given off to the abdominal organs, the stomach, pancreas, spleen, intestines, liver, kidneys, and other viscera. In the pelvis the aorta divides into two branches, one of which goes to each of the inferior extremities, the plan of distribution in the lower limbs being similar to that in the arms.

The large pulmonary artery which leaves the right ventricle is distributed wholly to the lungs.

The Capillaries.—These are the smallest of the blood-vessels. They are so very small that they can only be seen with a good microscope. Their walls consist only of the lining membrane of the arteries. They form an intricate meshwork through all the soft tissues of the body. The size of the capillaries is generally not more than $\frac{1}{3000}$ of an inch, and sometimes less.

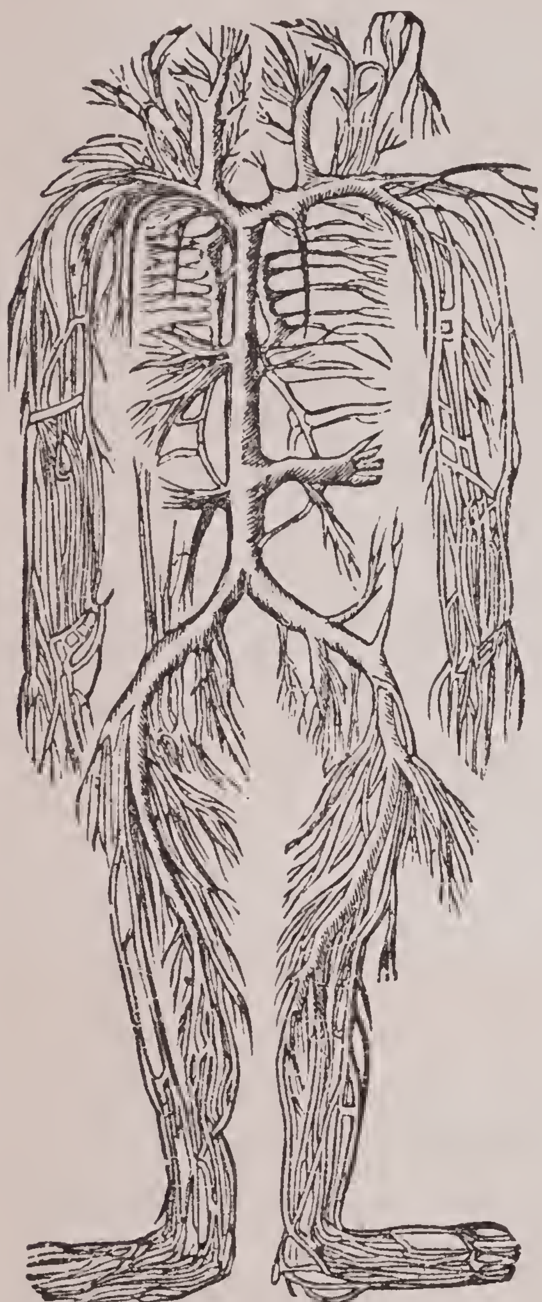


Fig. 94. The Venous System.

The Veins.—The veins begin with the capillaries, and gradually increase in size as they approach the heart, by the joining together of branches from different parts of the body. The veins differ from the arteries, 1. In being more numerous, there usually being two veins for one artery; 2. In having flaccid walls which collapse when they are not filled; 3. In having little or no muscular fibre in their walls, so that they cannot contract as do the arteries; 4. In having valves in some parts of the body which allow the passage of blood in only one direction,—toward the heart; 5. In communicating freely with each other by connecting branches. The location of the valves can be readily seen by tying a cord around the arm, thus interrupting the flow of blood. In a few seconds the veins of the hand and arm will be very much swollen with blood, and at regular intervals along the vein, about an inch apart, will be noticed little prominences which mark the location of valves. Fig. 94 gives a general view of the Venous System. The valves are well shown in Figs. 95 and 96.

The veins usually correspond in name to the arteries which they accompany. A few of the most important are, the ascending and descending *venæ cavæ,* which gather all the blood from the veins of the upper and lower parts of the body respectively; the *innominate,* which collects the blood from the head and upper extremities; the *jugular,* which returns blood toward the heart from the brain and

head; the *portal* vein, which collects the blood from the stomach, pancreas, spleen, and intestines, and conveys it to the liver; the *hepatic* vein, which conveys blood from the liver to the ascending *vena cava;* and the four *pulmonary* veins, which convey the blood from the lungs to the left auricle of the heart. For a representation of the system of blood-vessels, see Fig. 93.

Fig. 95.

Fig. 96.

Fig. 95. Valves of veins closed.

Fig. 96. Valves of veins as they appear when a vein is slit open.

Action of the Heart.—Like all other muscles, the function of the heart is to contract. In doing so it expels from its cavities the blood contained in them, just as water is pressed out of the rubber bulb of a syringe. Each portion of the heart goes through a rhythmical action of contraction and dilatation, the two hearts, or right and left side of the heart, if it be considered as one, acting together. The auricles, contracting, send the blood which they contain through the mitral and tri-cuspid valves into the ventricles. When the ventricles contract, they send their blood through openings guarded by the semi-lunar valves into the aorta and pulmonary artery. This action is shown in Figs. 97 and 98.

This action of the heart occurs about seventy-two times a minute, or four times for each respiration, and is called the heart-beat.

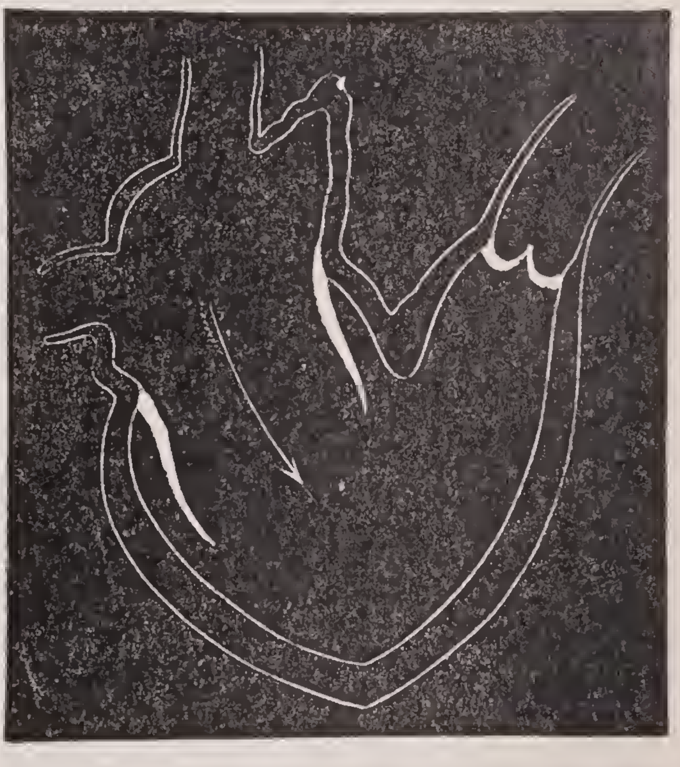


Fig. 97. Diagram showing Valve between Auricle and Ventricle open, and Semi-lunar Valve closed, allowing the Ventricle to fill.

Heart Sounds.—The beating of the heart is accompanied by two sounds, the first of which is produced by the striking of the apex of the heart against the wall of the chest, by the muscular contraction of the heart, and by the closing of the valves between the auricles and the ventricles. The second sound is a short click made by the semi-lunar valves as they close together after the blood has been forced from the ventricles into the arteries, to prevent its return into the heart.

Amount of Work Done by the Heart.—Various estimates have been made of the force exerted by the heart in driving the blood through the arteries. Recently it has been shown very conclusively that the left ventricle exerts a force of no less than fifty pounds in its contraction, that of the right ventricle being only about one-third as much, and the auricles about one-tenth as great. Adding together the force exerted by the different portions of the heart at each beat, we have an aggregate of over seventy-five pounds. By this is meant that the heart exerts, each time it beats, a force as great as would be required to lift seventy-five pounds a foot high. To ascertain the amount of work done by the heart, then, we have only to multiply the amount of work done at each beat by the number of beats in a given time. The average rate is seventy-two beats a minute, which would be 4,320 an hour, and 103,680 in a day of twenty-four hours. Multiplying the last amount by seventy-five, gives us 7,776,000 pounds as the entire work done by the heart during one day, which is equivalent to lifting 3,888 tons a foot high in a minute. This amount seems so enormous as to be almost incredible; but there is no doubt of the correctness of the estimate.

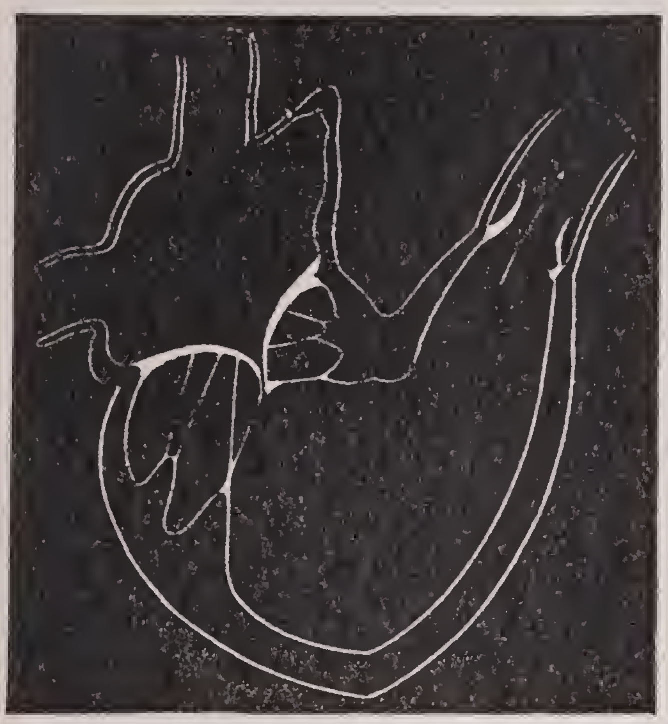


Fig. 98. Diagram showing Valve between Auricle and Ventricle closed, and Semi-lunar Valve open, allowing blood to pass into the Arteries.

The wonderful vitality of the heart is shown not only by the amount of work done by it, but by the remarkable tenacity of life which it manifests, continuing to work under the most embarrassing circumstances, as in disease, and when other important parts of the body have ceased to act. In cold-blooded animals it will even continue its rhythmical contractions for hours after the animal is killed and the heart taken from the body. The heart of a turtle can be made to contract more than twenty-four hours after being removed from the body of the animal.

Although the heart seems to be in such constant activity, some

part of it is always at rest, each acting part taking a short rest after each contraction before acting again. The heart in this way obtains nine or ten hours of rest out of each twenty-four.

The Pulse.—When the heart contracts, a wave-like impulse is sent throughout the whole arterial system, traveling from the heart to the remotest part of the body in about the sixth part of a second, so that it is practically instantaneous. Where the arteries come near the surface, this impulse may be felt, and is called the pulse. The most convenient place for feeling the pulse is in the radial artery just above the wrist, on the outer or thumb side of the arm. It may also be felt in the carotid artery of the neck, the temporal artery of the temple, and in many other localities.

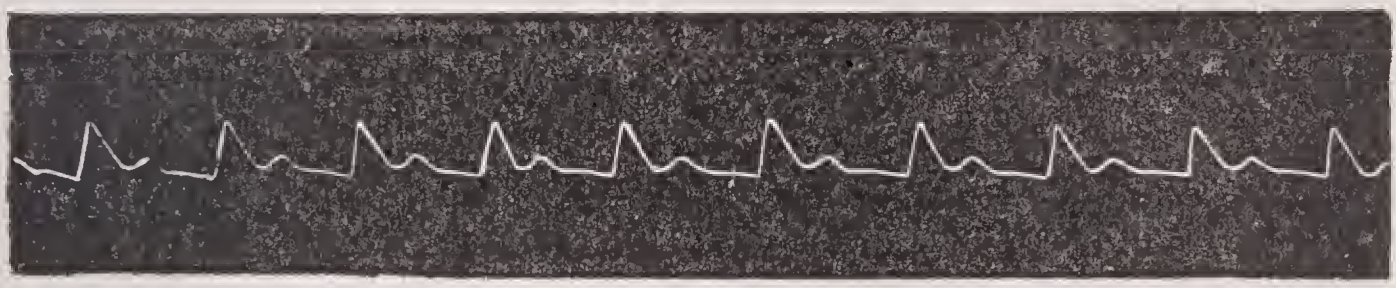


Fig. 99. Tracing of the pulse obtained by the sphygmograph.

An ingenious instrument known as the *sphygmograph*, the use of which is described elsewhere, has been invented within a few years, by which the character of the pulse may be more carefully studied than with the finger. The tracing shown by the white line in Fig. 99 we obtained with one of the latest and most improved forms of the instrument, known as Pond's Sphygmograph, a cut of which is shown elsewhere. As the pulse is really an index to the condition of the heart, it becomes also a good indicator of the general condition of the system, and much valuable information can be gained from its careful study. The various indications of the pulse are given elsewhere.

Frequency of the Pulse.—The pulse, of course, corresponds exactly with the heart-beat in frequency, and whatever modifies one affects the other as well. The usual average rapidity is about seventy-two beats a minute. This rate is very considerably modified by various influences, some of which may be mentioned with advantage.

1. The frequency of the pulse greatly depends upon the age. At birth the pulse rate is 136; from two to seven years, 97; fourteen to twenty-one, 76; twenty-eight to thirty-five, 70; fifty-six to sixty-three, 68; seventy-seven to eighty-four, 71. In females the pulse is seven to ten beats faster than in males. The average rate of pulsation in males, from two to eighty years, is 73; that of females is 82.

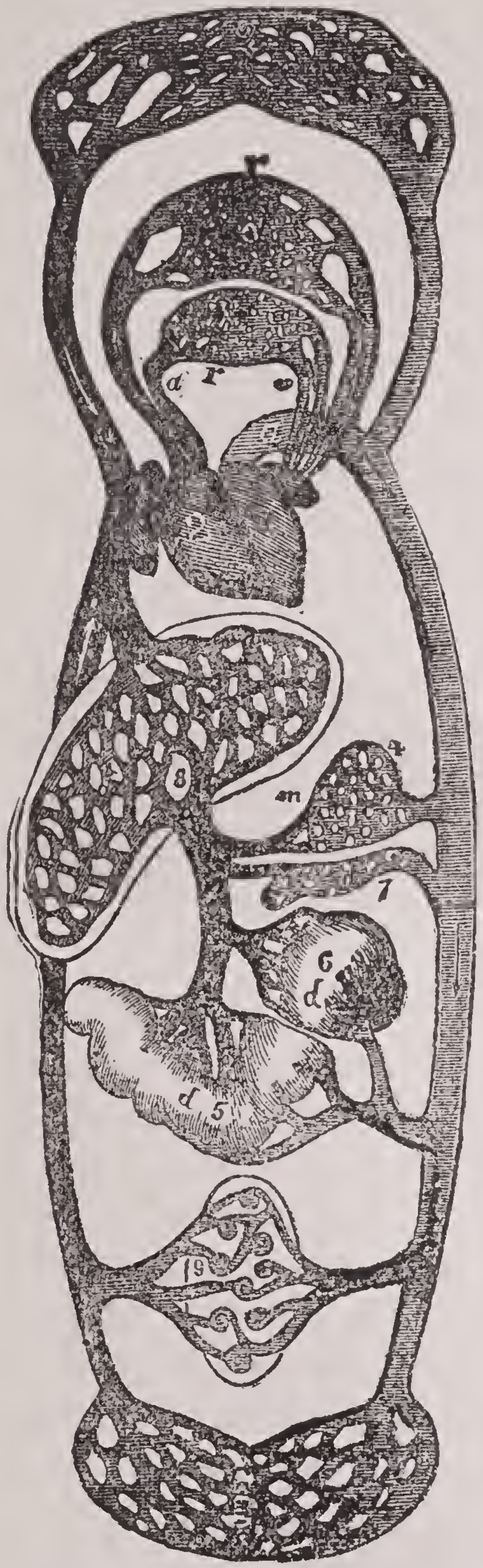


Fig. 100. A Diagram of the Circulation. 1. Left Ventricle; 2. Right Ventricle; 3. Liver; 4. Spleen; 5. Intestines; 6. Stomach; 7. Pancreas; 9. Urinary and Sexual Organs; *a.* Aorta; *r r.* Lungs; *a.* Pulmonary Arteries; *v.* Pulmonary Veins.

2. Posture modifies the pulse rate. For example, it has been found that the pulse of a person whose heart beats 66 times a minute while lying down will be about 71 when sitting, and 81 when standing.

3. The frequency of the pulse is affected by temperament. In some persons the pulse is naturally much more rapid than in others. Some persons have remarkably slow pulses. Both Napoleon and Wellington had pulses remarkable for their slowness, not averaging more than fifty beats a minute. We once met a case, that of a young lady, in which the pulse was but thirty-two; another patient, a young man who was in a very debilitated condition, we found with a pulse of but thirty.

4. Digestion increases the heart-beat from five to ten per minute. The increase in frequency of the pulse is particularly marked after a meal consisting largely of flesh food.

5. The influence of exercise upon the heart's action is very great. A person whose pulse is 68, after a slow walk will have a pulse of 78; after walking at the rate of four miles an hour, 100; and after a rapid run, 140 to 150. In children and women the pulse is considerably slower during sleep than when simply reclining while awake. In adult males there seems to be no difference.

6. The heart's action is greatly accelerated by a high temperature, and is retarded by cold. A Turkish or Russian bath or a warm full bath will occasion a very considerable increase in the activity of the heart. The pulse of persons living in warm climates averages greater than that of those living in cold climates.

A curious account is given by physiologists of a man who possessed such control of his heart as to be able to suspend its action altogether. On one occasion he remained for half an hour appearing as though dead, neither respiration nor heart action being perceptible. Several medical men were present.

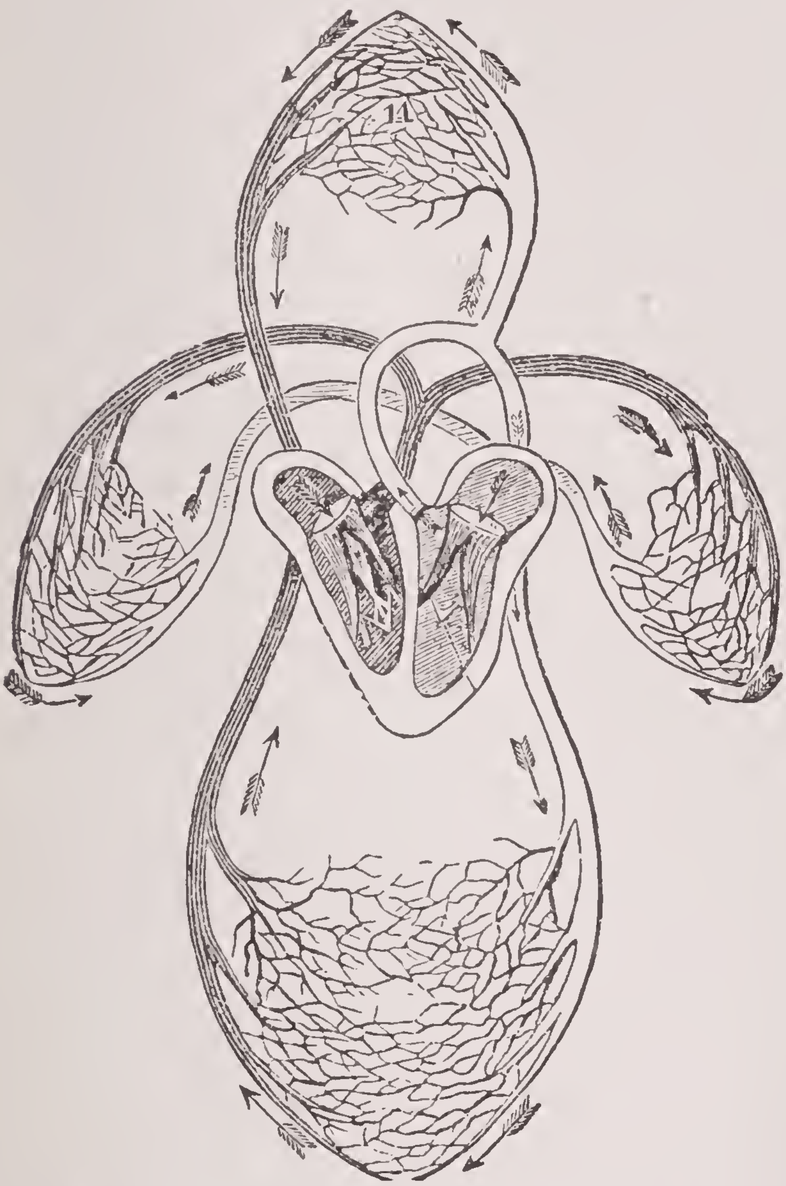


Fig. 101. Diagram of the Circulation, showing by means of arrows the direction of the blood current in the blood-vessels.

The Course of the Blood in the Circulation.— The circulatory apparatus of the system may be divided into three distinct circulatory systems; viz., the general or *systemic*, the *pulmonary*, and the *portal*. These three systems and their relations to each other and to the heart are shown in Figs. 100 and 101, and still better in the diagram on Plate V. The general course of each of these three systems we will now trace.

The Systemic Circulation.—The circuit of blood for the body in general starts at the left ventricle of the heart. By the contraction of the heart the blood is forced into the aorta, and as the semi-lunar valves close tightly behind it, each succeeding contraction forces the blood farther on in the arteries until it is thus propelled to the minute capillaries of the whole body. In these the blood flows very slowly, the motion often being imperceptible. The capillaries finally merge into veins, which gradually grow larger in size and smaller in number until they finally all unite to form two great venous trunks, the *ascending vena cava,* which conveys to the heart all blood from the lower part of the body, and the *descending vena cava,* which empties into the heart all the blood from the upper part of the body. The two vessels empty their contents into the right auricle. This completes the circle of the

systemic circulation, which, as will be observed, conveys the blood from the ventricle of the left heart to the auricle of the right heart.

The Pulmonary Circulation.—In order to provide for its purification, we have a second system through which the blood is circulated. In this system the blood which is received into the right auricle from all parts of the body is forced by its contraction into the right ventricle, whence it is forced into the pulmonary artery. This artery conveys it to the lungs and distributes it in a special set of capillary vessels in which it undergoes purification, and is then, by means of the pulmonary veins, conveyed back to the heart, which it enters at the left ventricle. It is thus seen that the pulmonary circulation forms a circuit for the blood from the right ventricle of the heart to the left auricle, whence it enters the left ventricle and again begins its round in the systemic circuit.

The Portal Circulation.—This system is really a subdivision of the systemic circulatory system. The blood which is distributed to the stomach, intestines, pancreas, and spleen, instead of returning with the rest of the blood of the general system direct to the heart by means of veins and the vena cava, is collected from all these organs by a large vein known as the portal vein, which conveys it to the liver, where it is distributed through a special set of capillaries provided to enable the liver to perform its special functions upon the blood, removing impurities, completing the work of digestion to some extent, etc. All the elements absorbed by the veins of the stomach during digestion are thus submitted to inspection before being allowed to enter the general circulation. From the liver the blood is carried to the ascending vena cava by means of the hepatic vein, and thus the portal circulation is completed.

Forces of the Circulation.—The heart, although the chief, is not the only active agent in the circulation of the blood. Several agents have part in the work, the principal of which will be enumerated as follows:—

1. *The Heart.*—As already seen, the force exerted by the heart amounts to about seventy-five pounds each beat; and although this force is sufficient to propel the blood to the capillaries, so large an amount of friction results from the immense surface over which the blood passes in the capillaries that additional force is required. Again, there is good evidence for believing that the blood will continue to circulate without the action of the heart, the arteries being always found empty when examined after death, though they must have been full

when the heart ceased its activity. In some low animal forms, too, the circulation is carried on without the aid of the heart, just as the sap is circulated in a plant.

2. *The Arteries.*—The contraction of the heart, which gives the blood a propulsive impulse, is followed up by the contraction of the arteries. The small arteries are supposed to be specially active in assisting the circulation. Some observers claim that the small arteries or arterioles keep up a constant peristaltic action, by means of which the blood is urged forward.

3. *The Capillaries.*—While the capillaries themselves are simply passive agents, the passage of the fluid part of the blood through their walls must occasion a capillary action similar to that which causes the rising and circulation of sap in trees and plants. It is claimed by some physiologists that the circulation is aided by the attraction of the walls of the capillaries for the nutritive elements of the blood. It is proven, at any rate, that blood which is well oxygenated passes readily through the capillaries, while that which contains carbonic acid is very much retarded in its progress in this part of the circulation.

4. *The Muscles and the Valves of the Veins.*—The veins are so placed among the muscles that whenever contraction of the muscles occurs they are compressed, and the blood which they contain is necessarily displaced. As it cannot pass backward, on account of the valves which close whenever a backward current is established, it must of necessity move forward. Contraction of a muscle has essentially the same effect upon it that squeezing has upon a sponge filled with water. This is undoubtedly an important aid to the venous circulation. See Fig. 102.

Fig. 102. Diagram showing how the valves of the veins aid the circulation by preventing back current.

5. *Heat.*—It is probably true that in certain parts of the body, at least, the elevation of temperature which the blood undergoes in the capillaries aids the circulation by increasing its volume, the pressure of blood from behind compelling expansion in one direction, toward the veins.

6. *The Lungs.*—The lungs operate with considerable force in aiding at least a portion of the venous circulation. When the chest is expanded, and while it is filling, the pressure being partly removed from the large veins which pass through the chest, the blood rushes in to fill them. In this way much assistance is especially afforded to the circula-

tion of blood in the liver, which is a wise provision of nature, as it will be observed, by reference to the diagram of the circulation, PLATE V, that the blood of the portal system passes through two sets of capillaries, the double amount of friction thus produced having a strong tendency to render the circulation in the liver sluggish.

Regulation of the Circulation.—The heart's action is under the immediate control of the nervous system. Each beat of the heart is in obedience to an impulse sent to it from the nerve centers of the brain and spinal cord. In order to provide for the various exigencies which make necessary an increase or diminution of the action of the heart, two sets of nerves are provided, one of which accelerates the action of the heart, while the other slows its contractions. The first function is performed by the sympathetic nerves, the second by the pneumogastric. By the action of these nerves the supply of blood to the general system is regulated according to its wants. For example, when a person is engaged in active exercise the muscles and nerves demand an increased supply of nourishment, which can only be furnished by an increased supply of blood. The increased waste also demands a quickened circulation to remove the products of the disintegration due to muscular activity. Hence the pneumogastric nerve releases in part its hold upon the heart, and the sympathetic nerve increases its action. Every part of the body receives an increased supply of blood, those not engaged in active exercise, to some degree at least, as well as those which participate in the activity.

Regulation of Local Blood Supply.—In addition to the nerves already referred to, there is a set of nerves which accompany the blood-vessels in their minutest subdivisions and remotest ramifications, by means of which the circulation of each organ, even each small portion of the body, is controlled. The nerves are connected with a collection of cells in the medulla oblongata known as the vaso-motor center. When an impulse is sent out from this center along any of the nerves which go out from it, the muscular walls of the small arteries to which the nerves are distributed are caused to contract, and thus a less amount of blood is allowed to flow through the part. When a slight degree of excitation of the nerves is kept up by the center, the walls of the arteries become relaxed, so that by their dilatation a much larger amount is allowed to flow through them than before. An experiment often performed by physiologists well demonstrates this action of the vaso-motor nerves. The vaso-motor nerve of the ear of a white rabbit being di-

vided, the white skin of the ear quickly becomes red, being congested with blood, the result of paralysis of the small arteries of the part. If the end of the divided nerve be stimulated by electricity, the arteries will at once contract and the skin assume its natural color.

Blushing is due to the dilatation of the small arteries of the face from the effect of certain emotions upon the vaso-motor center in the brain. The paleness due to fright and extreme rage results from contraction of the small arteries induced in the same way.

The circulation of blood in the stomach, liver, and other internal organs, as well as in all other distinct parts of the body, is controlled by dilatation and contraction of the small arteries, in the manner described.

THE BLOOD.

The blood is a fluid tissue. In the body there are tissues of all degrees of consistency, from the dense bones and tendons to the perfectly fluid blood. It is a highly vitalized fluid, not a mere chemical solution. The blood contains all the elements necessary for the building up and keeping in repair of all the various tissues of the body. In addition to nutritive elements the blood also contains the various effete or waste products which result from the breaking down of the various tissues as the result of vital action. It not only supplies nourishment to the hungry tissues but washes them free from the noxious products of daily waste.

The quantity of the blood has been variously estimated, the estimates varying from ten to eighteen pounds, or about half as many quarts.

Composition of the Blood.—To the unassisted eye the blood appears to be a homogeneous fluid, of a reddish color which varies from the bright red of the arterial blood to the dark purple blood found in the veins. When examined with a microscope of sufficient power, the blood is found to be made up of about equal quantities of fluid and certain minute solid bodies floating in the fluid, called blood corpuscles, of which there are two varieties, *white*, and *red*, each of which we will describe.

White Blood Corpuscles.—The microscope reveals in the blood minute protoplasmic bodies, resembling drops of transparent jelly, which constitute the white blood globules or corpuscles. PLATE VI. These minute specks of life may be considered as independent individuals, since

they may be removed from the body and kept alive for weeks. A scientific writer not inaptly calls them little fishes swimming in the life-current which flows through the veins and arteries. So small are these little creatures that twenty-five hundred of them arranged in a row would make a line but an inch in length. When examined closely the white corpuscles may be seen to have in their central portion minute granular specks. See Fig. 103.

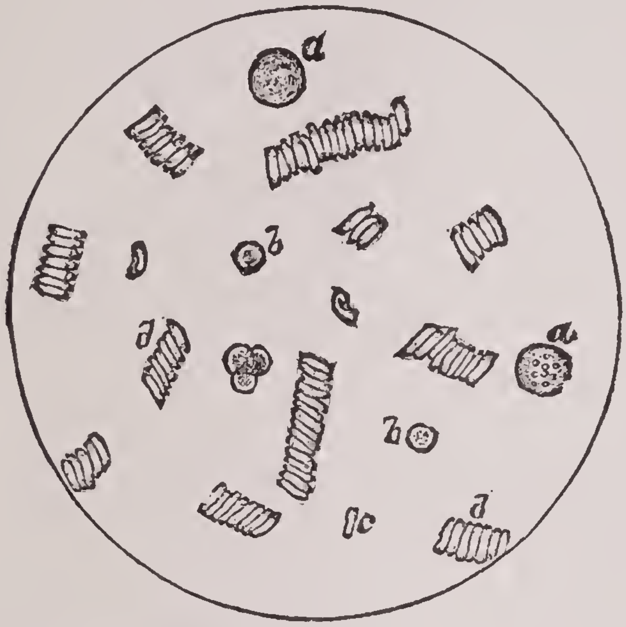


Fig. 103. Red and White Blood Corpuscles. *a.* White Blood Corpuscle; *b.* Red Corpuscle; *c.* Red Corpuscle, showing edge; *d.* Red Corpuscles in rolls, an evidence of health.

The white corpuscles are supposed to have their origin in the lymphatic glands, in which corpuscles exactly resembling them, and known as lymph corpuscles, are found in great numbers. When carefully studied under various circumstances they are found to undergo a regular process of growth and development like large animals, finally growing old and at last dying and being removed from the body, cast out as dead bees are thrust out from a hive by the living workers. While in their active state these remarkable little bodies exhibit many wonderful properties. Though they have no organs of locomotion, they are able to move from point to point with ease and considerable rapidity. Having no mouths, they are yet voracious eaters. Though possessing no nerves or organs of any other sort, they appear to be exceedingly sensitive to heat and cold, electricity, and other agencies which in higher forms of life are recognized by organs of sense. How these functions are performed by the white blood corpuscle,—sometimes called the animalcule of the human blood,—we need not dwell upon in detail here, as the same subject has already been more fully explained in another connection.

What are known as mucous, lymph, and pus corpuscles are apparently identical with white corpuscles.

The Red Blood Corpuscles.—Besides the white corpuscles just described, and constituting by far the largest share of the solid constituents of the blood, are found the red blood corpuscles. See

Fig. 104. Like the white corpuscles, the red are exceedingly minute, from three thousand to thirty-five hundred being required to form a row an inch in length. The red corpuscles differ from the white in several particulars. Instead of being globular, they are bi-concave and disc-like in form, being about one-fourth as thick as broad. Instead of being transparent, or gray in color, they are of a faint amber color, the red color of the blood resulting from the massing together of such immense numbers as are found in the vital fluid. It has been recently determined that there are more than 3,000,000 of these delicate bodies in a drop of blood no larger than can be made to hang upon the point of a pin. There are no less than 30,000,000,000,000 red corpuscles in the whole body. The red are much more numerous than the white corpuscles, in health, the average proportion being about 300 red to one white. The proportion of white corpuscles is greater just after a meal, and in certain forms of disease they occasionally become so numerous as to equal in numbers the red corpuscles, a condition which is very unfavorable to life.

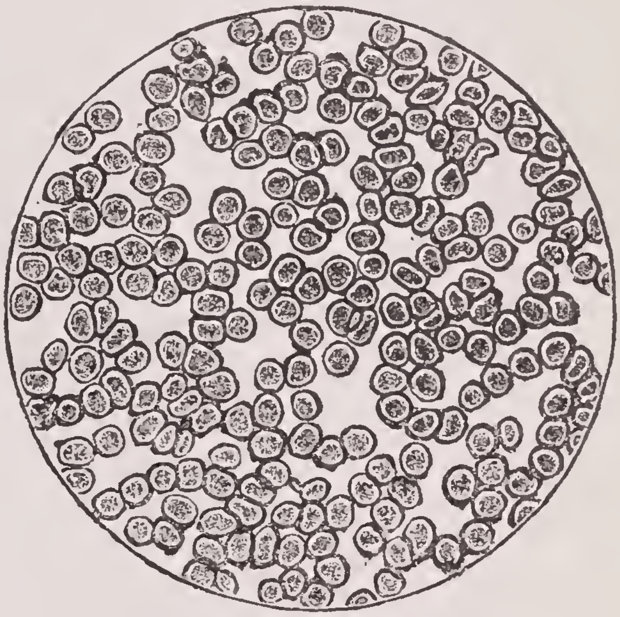


Fig. 104. Red Blood Corpuscles.

The color of the corpuscles is due to a peculiar kind of coloring matter which they contain. By means of this singular substance, as is supposed, the corpuscle acquires the power to absorb many times its own bulk of certain gases, a property similar to that possessed by fresh charcoal, which is rendered a good filtering medium on account of the large amount of condensed oxygen stored up in its pores. The color of the corpuscles differs according to the character of the gas which they are carrying, they being of a bright color when carrying oxygen, and darker when carrying carbonic acid, thus occasioning the difference in color between arterial and venous blood, as will be further explained in treating on the subject of "Respiration."

The origin of the red corpuscles was for years a puzzle to physiologists; but an ingenious German solved the problem by removing a

small quantity of blood from the body and carefully watching it for a sufficient length of time to witness the actual development of red corpuscles. The blood, by being kept at the temperature of the body and in a moist atmosphere, seemed not to suffer by its removal; and the patient observer was rewarded for his pains by seeing white blood corpuscles gradually turn into red ones, thus demonstrating that red corpuscles are simply white ones grown old.

Each corpuscle acts a part in the body but a brief period, as it passes quite rapidly through its various stages and becomes useless, when it is destroyed and removed from the body. The spleen and liver seem to be the most active blood-destroying organs. The coloring matter of the blood corpuscles after their destruction is converted into the coloring matter of the bile.

The blood corpuscles of animals resemble more or less closely those of human beings. Those of the dog are so near like human blood corpuscles as to be scarcely distinguishable. Those of the goat, sheep, and ox, are much smaller, and those of the elephant much larger than those of human beings. The corpuscles of the camel and llama are elliptical in shape, as are also those of birds, reptiles, and fishes. In the three last-named classes of animals the corpuscles are bi-convex instead of bi-concave.

The Liquid Portion of the Blood.—The liquid half of the blood may be regarded as a solution of albumen, containing also small quantities of fat, certain salts, waste products, and gases.

When exposed to the air the albuminous constituent of the blood is decomposed very quickly, one portion becoming semi-solid. This is what is known as coagulation of the blood. The part which coagulates is ordinarily known as fibrine. The albuminous elements of the blood are its chief nutritive elements. From these the tissues derive the material from which they are formed. While in solution in the fluid portion of the blood, or *plasma*, they permeate every organ and tissue of the body, thus bathing with a nutritive fluid all the tissues requiring repair. It is a curious fact that the fluidity of these elements seems, in some degree at least, to depend upon their constant motion, for blood soon coagulates when stagnation occurs. Any foreign body introduced into a blood-vessel will also occasion coagulation. In inflammation and some other conditions the tendency to coagulation is increased.

The proportion of fat is ordinarily very small, being not more than

one part in twenty-five hundred of blood, or .04 per cent. After a meal consisting largely of fat, a much larger quantity may be found in the blood. In the blood of habitual drunkards, fat is also usually found in greatly increased quantities.

The various analyses which have been made for the purpose of determining the saline constituents of the blood seem to us to be less reliable than would at first appear, since they do not take into account the nature of the individual's food. We have no doubt that a large share of the so-called saline constituents of the blood are both unnatural and unnecessary elements in the quantities in which they are usually found, and that they only occur in the blood incidentally, having been taken in excess in the food, and being absorbed and carried by the blood to the various organs capable of eliminating them. This seems to be particularly true of the various compounds of soda, especially sodium chloride, or common salt, which is found in the human system almost exclusively in the blood, merely a trace being found even in the bones, the hardest of all the tissues of the body.

Functions of the Blood.—As before remarked, the blood not only supplies to the various tissues material from which they may replenish themselves, but washes them free from the poisonous products of vital activity, which are conveyed to the various organs designed to remove them. It will be interesting to consider briefly the work performed by the two varieties of corpuscles found in the blood and already described.

Function of the White Blood Corpuscles.—The principal use of the white corpuscles probably is to ultimately become red ones, which have the most important work to perform. It is probable, also, that the white corpuscles have something to do with nutrition, since it has been noticed that they are most abundant at points where some injury has occurred or where repair is necessary for some other cause.

Function of the Red Blood Corpuscles.—The red blood corpuscles are probably the most immediately necessary to life of any of the elements of the body, if we except some of the nerve centers. This is well shown by the fact that many persons when nearly dead from loss of blood have been quickly recovered by the injection into the veins of fresh blood from which the fibrine had been removed, leaving only the corpuscles and serum. When serum alone has been used, no appreciable result has been obtained, but when the corpuscles are used with the serum, even though the nutritive fibrine be removed,

the effect is sometimes almost as marvelous as the restoration of the dead to life. Indeed, it is stated on good authority that a dog which had been bled to death, after having blood from a living dog injected into his veins, got upon his feet and walked a short distance. Almost equally marvelous experiments have been made with human beings, decapitated criminals being used for the purpose.

The chief business of the red corpuscles is to carry oxygen from the lungs to the tissues. Oxygen is the most essential to life of all the elements received into the system. The lungs are the organs by which it is taken into the body, and the red blood corpuscles act as carriers to distribute it. Each corpuscle takes on a load of oxygen about twenty times its own size, condensing it so as to make it portable, and this it carries to the capillaries, where the load of oxygen is laid off and a smaller load of carbonic acid taken on, the latter being carried to the lungs and discharged, and a new load of oxygen taken on.

An Interesting Sight.—One of the most interesting of all the many marvelous sights revealed by the microscope, and one of great beauty and interest, is that of the circulation of the blood. The most convenient object for a demonstration of this kind is the tail of a young tadpole. The tissues near the end of the tail are so thin as to be translucent, so that sufficient light will pass through to form an image in the microscope. Almost any thin tissue can be used in the same way, as the web of the hind foot of a frog, the mesentery of a rat, or the ear of a bat. By placing one of these objects under the microscope a most marvelous sight is beheld. One who has once seen it will never forget it. On PLATE V will be found an excellent representation of what may be seen with the microscope. We have never watched this wonderful spectacle without feeling impressed anew with the power and wisdom of the Great Designer and Creator of all nature. As will be seen by reference to the engraving, the capillaries form a close network of minute canals through which the blood corpuscles course in narrow lines. In the smallest capillaries they follow each other in single file; through the larger ones they pass in twos. In some of the smallest vessels the corpuscles seem to squeeze through with difficulty, being actually larger than the vessels through which they pass, which seeming impossibility they accomplish by changing their form, becoming elliptical, and going through their long way.

Close inspection will bring to notice the fact that the red corpuscles in their passage through the capillaries file along in the center of

the vessel, while the white ones seem to loiter along the walls, stopping here and there a few seconds and then lazily pulling themselves along a short distance farther. If watched closely they may be seen, now and then, to make their way out of the blood-vessels in a curious fashion, by tucking themselves through the minute openings in the capillary walls very much as a ball of putty might, by changing its form, be tucked through a finger-ring. The red corpuscles sometimes accomplish the same feat, though very seldom. The corpuscles which thus leave the blood channels do not find their way back again, but are carried to the heart by means of the lymph channels,—to be next described,—thus being saved and again used so long as they are serviceable.

The capillary circulation has recently been observed in human beings by an eminent physiologist who discovered a means of making visible the capillaries and corpuscles in the lip.

THE LYMPHATICS.

The lymphatic system differs from the circulatory system of blood-vessels in that it has but one set of vessels, all of which run in the same direction, toward the center of the body. The lymphatic system also differs from the arterial and venous systems in that it has few large trunks, being almost wholly made up of minute vessels which constantly communicate with each other in all parts of the body. In certain localities there are found small glandular bodies about which the lymphatic vessels seem to collect, or from which they seem to radiate. These are known as lymphatic glands. They are chiefly found in the vicinity of the groins, the armpits, the neck, beneath the knee, in the bend of the elbow, and among the folds of the small intestine. See Figs. 105, 106, and 107.

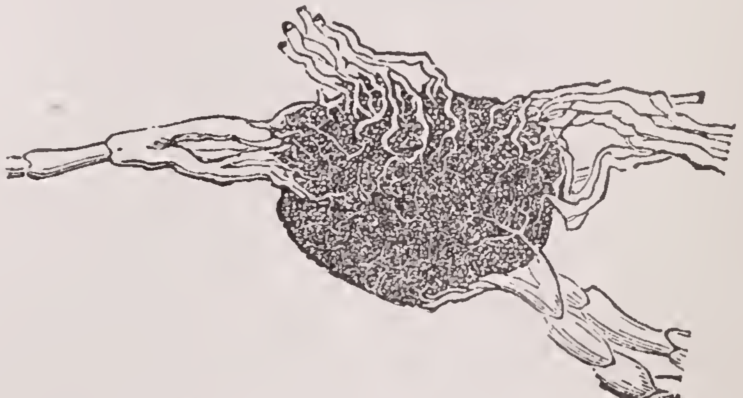


Fig. 105. Lymphatic Glands.

The smallest vessels seem to originate in the connective tissue spaces, in all parts of the body. In the mucous membrane of the small intestine they originate in minute protuberances known as *villi,* which will be described hereafter. All the lymph vessels of the lower extrem-

Fig. 106. The Lymphatic Vessels and Glands of the head and neck.

ities, the abdomen, and left half of the upper part of the body, empty their contents, directly and indirectly, into a large duct known as the thoracic duct, which passes up at the back part of the cavity of the abdomen and the thorax and empties into the left subclavian vein. Those of the right half of the upper part of the body are drained by the lymphatic vein, or duct, which empties into the right subclavian vein.

The contents of the lymphatic vessels is a clear, limpid fluid, which, when examined chemically and microscopically, is found to contain a fluid substance similar to the serum of the blood, except that it contains more of the waste or excrementitious elements than the blood. It also contains large numbers of corpuscles called lymph corpuscles,

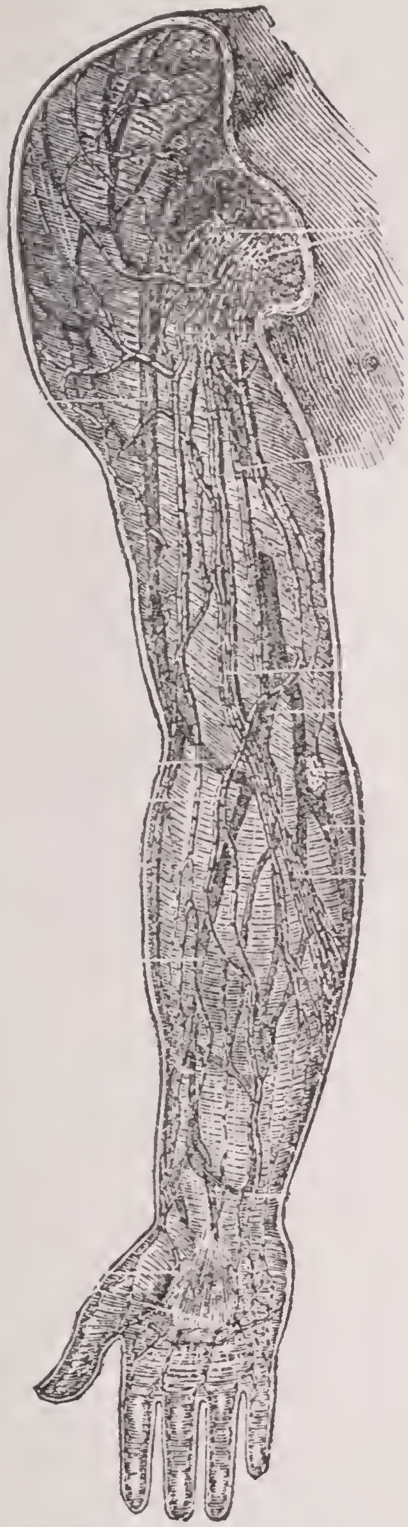


Fig. 107. Shows Lymphatic Vessels of the arm.

which are similar to, and undoubtedly identical with, the white corpuscles of the blood. The motion of the lymph fluid is toward the center of the circulation, being only in one direction. Like the venous system, the lymph vessels have valves so arranged as to allow of a current in but one direction. These valves are much more numerous in the lymphatics than in veins, as will be seen by reference to Fig. 108. In some lower animal forms, as in frogs, there is a distinct lymph heart which propels the lymph fluid in the vessels. There is no such force in operation in man and higher animals, however, and it is probable that the current of fluid in the lymphatics is chiefly due to the forces which aid the venous circulation; viz., the pressure of fluid from the heart, which is being constantly propelled into the tissues, the contraction of the muscles, acting in conjunction with the valves, and the suction force of the lungs in the act of inspiration.

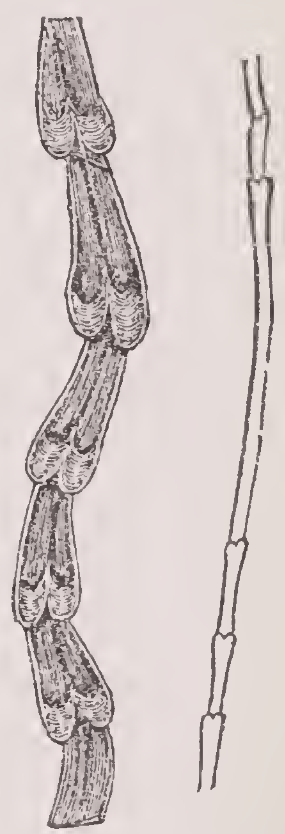


Fig. 108. The Lymphatic Vessels showing Valves.

Functions of the Lymphatics.—As would be readily surmised from the structure of the lymphatic system, its principal function is absorption. From the skin, which is abundantly supplied with lymph vessels, water and many substances in solution may be absorbed, and thus taken into the system. A case is on record in which a boy in a London hospital, suffering with diabetes, absorbed nine pints of fluid through the skin in twenty-four hours. The portion of the lymphatic vessels which are most active in absorption are distributed in the mucous membrane of the intestines, where, as already remarked, special facilities are afforded for the absorption of fluids by means of villi, projections of mucous membrane which float in the fluid to be absorbed. Through these channels—in this

part of the body known as lacteals—much of the food finds its way into the system. Absorption is also going on all through the body. Worn particles and waste products of all the tissues find their way to the heart through the medium of the lymph vessels. It is through these channels, also, that the white blood corpuscles, which, as we have already seen, sometimes escape through the capillary walls, find their way back to the blood-vessels.

It is supposed, also, by many of the most eminent physiologists that the lymphatic glands manufacture white corpuscles.

HYGIENE OF THE CIRCULATION.

Although the heart and blood-vessels are the least subject to serious direct injury of any part of the body, the circulatory apparatus is of all parts of the system the most liable to derangement, from sympathy with other parts. No part of the system can become in any way impaired without affecting the circulation, so universal and intimate are the sympathies established by the nervous connections of the heart and blood-vessels.

Exercise Necessary for a Healthy Circulation.—An abundance of muscular exercise is essential for the health of the circulatory apparatus. As already observed, the movements of the muscles in contracting squeeze the blood out of the small veins and press it onward toward the heart. This compels the heart to beat faster in order to dispose of the increased amount of blood which is brought to it, by which means two excellent results are obtained: 1. The impure, venous blood is sent to the lungs,—which in turn act with greater rapidity,—and is there purified and returned to the heart, so that the purity of the blood is increased by the exercise, notwithstanding some waste products from muscular action are added to it; 2. The heart, by beating faster, sends an increased supply of blood not only to the muscles, but to all the organs and tissues of the body; and thus each part is enlivened and invigorated by the increased quantity of fresh, vitalized blood circulating through it. This increased activity of the circulation is not only beneficial to the muscles, nerves, and other tissues of the body, but also to the heart and blood-vessels themselves. The heart is a muscle, and by vigorous contractions it becomes strong, as would any other muscle. The proportionate strength of the heart is well shown by a simple experiment. Let two persons, one who is not accustomed to active mus-

cular exercise, and another who uses his muscles vigorously every day, each count his pulse while standing. Now let both walk briskly or run a few rods, or up and down stairs two or three times. Upon counting the pulse a second time it will usually be found that the pulse of the sedentary person is very much more excited than that of the person accustomed to exercise. This shows that his heart is weaker, and is compelled to make much more violent exertions to accomplish a little extra work than a heart accustomed to demands of that sort. It is for this reason, mainly, that persons unaccustomed to running or walking usually get out of breath so quickly, while one trained in this kind of exercise will endure it with apparent ease for hours. Vigorous exercise, of course avoiding excess, makes strong muscles and a vigorous heart.

Dangers of Excessive Exercise.—While a proper amount of exercise is important and essential to the health of the circulatory system, it should be borne in mind that excess is not only detrimental but dangerous. Violent exertion on the part of one unaccustomed to exercise is often productive of the most serious injury; and even those who have been trained to violent exercises often suffer great detriment. Instances have occurred in which rupture of a blood-vessel has resulted from violent straining in lifting, jumping, or trapeze performances. It is well known that the valves of the heart in professional oarsmen are not infrequently torn loose by the strain induced by rowing. Under violent muscular exertion the pressure of the blood in the arteries is very greatly increased, hence the danger. Violent exercises should always be avoided as in no way beneficial, and always detrimental and dangerous. All the advantages to be gained by exercise can be derived from such moderate exercises as have already been recommended in connection with the subject of the "Hygiene of the Muscles," and will be more fully described in a chapter especially devoted to the subject.

Proper Clothing Essential to Healthful Circulation.—We cannot in this connection consider more of this broad subject of clothing than has an immediate bearing upon the subject in hand, and need not, as we have elsewhere devoted a chapter to its consideration. Undoubtedly the prime object in clothing is to satisfy the demands of modesty; but besides this, the greatest want supplied by artificial covering of the body is the necessity for an equable temperature. This can only be attained by clothing all parts of the body in such a manner as to secure the natural degree of temperature for its several parts, adapting the clothing to the climate and season of the year. Failure to regard this

law is probably more common than the opposite. One-half of the human family, at least, are habitually clad in a manner which totally ignores the requirements of nature in this regard. It is an exceedingly rare occurrence to find a woman who clothes her arms and limbs as nature requires them to be clad for health, at any rate among civilized nations. The women of barbarous tribes and nations are more sensible in this regard, and imitate their husbands and brothers in clothing their limbs as warmly as nature and the exigencies of climate demand. Civilized women not only neglect themselves—we should properly say abuse themselves—in this regard, but their children are allowed to suffer from the same cause. Thousands of these little innocents have been sacrificed to the insatiable Moloch of Fashion.

The extremities, being farthest from the great centers of heat and life, evidently need more clothing than other parts more favorably located; but they commonly receive less. This is an evil, the magnitude of which can scarcely be overestimated. We have no hesitation in venturing the assertion that thin shoes and stockings, and bare arms and legs, kill more children every year than the infamous Herod murdered in Bethlehem. Every philanthropist ought to join earnestly in the work of effecting a reform in this direction. Little reward can be expected, however, for this kind of work in the present generation. The results would be best seen in the next, in the effective labors of thousands whose lives are now made useless by disease, the foundation of which was laid in early childhood by the evil practice in question, and of thousands of others who to-day are filling tiny graves which ought to have remained vacant for at least threescore years. Every mother who becomes enlightened on this subject ought to communicate the knowledge she has gained to the mothers in the circle of her acquaintance. By this means, together with the influence of example, we might hope for good results. There has been recently organized in New York City a society, the stated object of which is the prevention of cruelty to children. We would most earnestly commend to their attention this question of proper clothing, and we doubt not that the amount of good they might do by propagating correct principles on this subject would far exceed the good results in all other departments of their work.

Evil Effects of Constriction.—Constriction of any part of the body is certain to be followed by evil consequences. Suppose, for example, a string be tied tightly around the finger. Every one is familiar with the fact that the finger thus ligated will speedily lose its

natural color, become dark and as quickly lose its natural warmth, becoming cold, and that notwithstanding its swollen condition due to the superabundance of blood. An elastic around a limb will have precisely the same effect upon the foot, though in less degree. The circulation being obstructed, less blood than is necessary to health flows through the foot, and it is habitually cold; and from the constant interference with its nutrition, it becomes shrunken and weak. The use of elastics is well known to be a cause of thin calves.

A constriction about the waist, from compressing the stomach, liver, and other internal organs, must do an immense amount of harm to the body by interfering with the functions of these important organs. It makes no difference whether the constriction is due to a tightly drawn corset or to the bands of skirts hung upon the hips, or to a belt tightly clasped; the effect is the same. An English medical journal is authority for the statement that in that country quite a large proportion of women upon whom *post-mortem* examinations are held are found to have their livers malformed from compression due to this very cause. We have seen cases in which the liver was cut nearly in two, and cases are reported in which the liver had actually been divided by this cruel process. By the interference with the circulation in abdominal organs, piles or hemorrhoids is induced, with painful local disorders peculiar to females.

Constriction of the throat is an evil not now so common as in former days when the old-fashioned cravat was worn; but occasionally care is not taken to secure the degree of freedom about the neck which is essential to health. It requires but a very slight constriction of the neck to interfere with the circulation of the head sufficiently to occasion very unpleasant and even serious symptoms, such as headache, dullness, and vertigo; even apoplexy may be induced in this way.

Effects of Food on the Circulation.—As the blood is made of what we eat, it is evidently of the greatest consequence that what is taken into the stomach for the purpose of making blood should be of the very best material. Poor food will make poor blood, which will, in turn, make all the tissues of poor quality. Certain kinds of food, as what is termed rich food, or that which contains too much of sugar, fats of various sorts, and condiments, deteriorate the blood, both directly and indirectly. Directly, by filling it with useless or superabundant material; indirectly, by rendering the liver sluggish and in-

efficient, thus occasioning an increase in the elements which ought to be removed as bile. Other foods damage the blood by filling it with material which is not only directly injurious to the blood itself, but to all the tissues with which it comes in contact, whether in finding their way into the blood through the stomach or out of it through the liver, kidneys, skin, bowels, and other eliminating organs. Of this character are most condiments, as will be shown in treating of the subject of "Food and Diet," as well as in connection with "The Hygiene of Digestion," to which we would invite the further attention of the reader.

Narcotics and stimulants must not be overlooked in this connection, for their influence for evil upon the heart and the circulation is too great and too well determined to allow of the possibility of doubt, or the need of waiting for further evidence. Alcohol, tobacco, hashish, opium, absinthe, even tea and coffee, must be included in the category of harmful agents of this class. The manner in which each of these agents operates in effecting its evil work must be left for special consideration in a chapter devoted to the subject.

Injurious Effects of Cold.—Cold paralyzes the heart, and to its depressing influence is due the fact that so large a proportion of aged persons die in the cold season of the year. Having lost in some degree their power to produce animal heat, they quickly succumb to the exposures incident to the inclement season of the year. Hence it is important that the old, of all others, should be warmly clad in winter. There are current many incorrect notions respecting the means of protection from the injurious influence of cold. The idea that stimulants will enable a person to withstand cold has been long exploded. The uniform testimony of physiologists and Arctic explorers is to the very reverse. Physiologists find by actual experiment, testing the temperature of a person both before and after the imbibition of spirits; that the temperature is uniformly lowered by alcohol in all forms. Arctic navigators say that for a man to take alcohol when traveling amid the snow and ice of the frozen regions of the North, where the temperature is often 70° F. below zero, is almost certain death. Alcohol makes a man feel warmer, but really abstracts heat from him. So with tobacco, which many persons habitually smoke, in the winter to make them warm and in the summer to keep them cool. It depresses the action of the heart, and consequently diminishes the amount of heat

produced. The best means of protection are those which will raise the vital tone, strengthen the force of the circulation, and thus increase the manufacture of heat, while proper means are taken to preserve and economize that which is produced. Cool bathing for the robust is a splendid method of augmenting animal heat. The use of the oil-bath is an excellent means of protection from cold. A gentleman who was able to speak from experience said very truthfully that an inunction was as good as an extra overcoat.

Many persons make the great mistake at the beginning of cold weather of shutting themselves up indoors with hot stoves or furnaces, confining themselves to avoid taking cold. This is the most certain way to prepare one's self to acquire a cold upon the slightest provocation. A person may become so tender and susceptible by following such a plan that simply opening the window for a breath of fresh air, stepping to the door to admit a friend, or the most trivial degree of exposure will be sufficient to bring upon him the most severe effects of "taking cold." All persons, particularly those who are specially sensitive to cold, even invalids, should, at the beginning of winter, begin to accustom themselves to cold. Thus by degrees their susceptibility may be overcome in a very large measure, if not wholly. Daily exercise in the open air, and a daily bath with friction of the skin and inunctions, with plenty of good food and abundance of sleep are also important means of fortifying the system against the ravages of cold.

Evil Effects of Heat.—Excessive heat has a still more disastrous effect upon the circulation than cold, as is evidenced by the large number of cases of sudden death which annually occur from "sunstroke" and "heat-stroke." That this malady is really due to heat and not to the influence of the sun, as many suppose, is evidenced by the fact that many cases occur among factory operatives, furnace men, stokers in ships, and other persons whose occupation is wholly indoors. The remedies for this affection are given in the proper place. As it is often fatal, its prevention is of equal importance with its cure. Those who have had the most extensive experience with this disease assert that those who suffer from it are, as a general thing, persons who are in a debilitated condition from overwork, loss of sleep, dissipation, the use of alcohol, or poor and insufficient food. Stimulants are especially conducive to the disease. All these predisposing causes should, of course, be avoided, as well as the exciting cause already indicated. Persons who are exposed to excessive heat in the summer season should take care to

keep the head cool, which may be accomplished by means of a cloth wet in water and worn inside the hat, by very frequent wetting of the head, by the use of umbrellas in the sun, and by other means which special circumstances may require or suggest. Fig. 109 illustrates a mode of keeping the back part of the head cool in hot weather which may be adopted with advantage by those whose occupation obliges them to be much exposed to the sun.

Fig. 109. A means of protecting the back of the head and neck from exposure to the sun.

The habit of frequently applying ice or ice-cold water to the head in hot weather is likely to be productive of injury. The head is cooled for the moment, but a reaction soon takes place, and then there is a greater determination of blood to the head than ever. It is best to employ for bathing the head, water which is only moderately cool, and then depend on the evaporation to produce the necessary cooling effect. Ice and iced-water should be used only in cases requiring sudden and extreme cooling of the head, and then should be continuously applied until the desired effect is obtained.

The natives of Africa protect themselves from the intense heat of the tropical sun to which they are exposed by smearing their bodies with *ghee*, a kind of ointment. It is difficult to see what benefit can be derived from such a proceeding, but it is possible that the smooth, oiled surface of the skin may reflect the solar rays of heat and thus protect the body from their influence, at least to some extent.

THE RESPIRATORY APPARATUS.

The respiratory apparatus consists of the air-passages, the lungs, and the thorax, each of which will be briefly described.

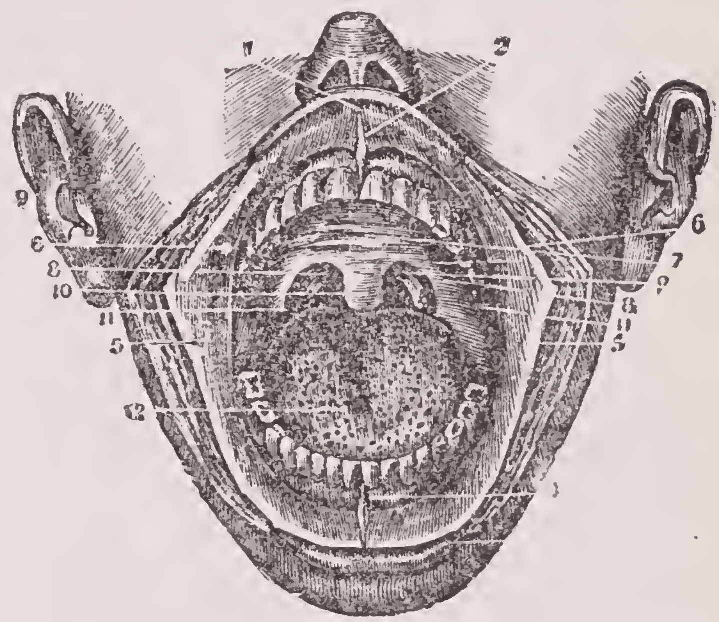


Fig. 110. The Pharynx, shown by slitting the cheeks at the corners of the mouth; 6. Mouth of duct from the parotid gland; 7. Roof of mouth; 8. Posterior nares; 9. Fauces; Uvula; 11. Tonsils; 13. Tongue.

The Air-Passages.—These consist first of the mouth, the nose, the *pharynx,* or back part of the mouth, the *trachea,* or windpipe, the upper part of which is also called the *larynx,* and the *bronchial tubes.* The mouth needs no precise description. The nose or nasal cavity consists of a hollow left between the bones of the face and those of the skull, which is divided into two parts by a bony and cartilaginous septum, each compartment communicating separately externally through the *anterior nares,* or nostrils, and with the back part of the mouth through the *posterior nares.*

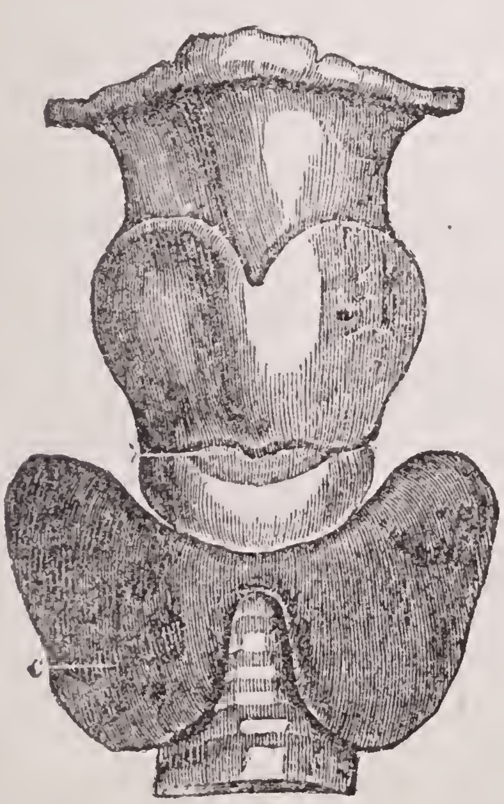


Fig. 111. The Larynx. 6. Thyroid Gland.

The *trachea,* or windpipe, is a flexible open tube situated just in front of the meat pipe, or gullet, and is composed chiefly of rings of cartilage connected together by membrane. These rings are not quite complete at the back side, the space being filled by muscular tissue.

The *larynx* is the upper part of the trachea, and consists of a cartilaginous box across which are stretched four delicate ligaments, the *vocal cords,* the upper two being the *false,* and the lower the *true* vocal cords, which are concerned in the production of the voice.

The top of the larnyx is guarded by a cartilage, the *epiglottis*, which is shaped somewhat like a leaf, and has a hinge-like attachment to the upper end of the windpipe, so that when the tongue is drawn back, as in swallowing, it will fit down upon the larynx like a cover, and completely close it. By this wonderful provision of nature, both solids and liquids are prevented from entering the trachea while eating or drinking. A patient in Bellevue Hospital, New York, whose epiglottis had been destroyed by disease, had great difficulty in swallowing on account of the frequent entrance of particles of food into the trachea, causing violent coughing. The cartilages of the larynx form the prominence in the throat just below the chin, which moves up and down in swallowing, and is popularly known as Adam's apple.

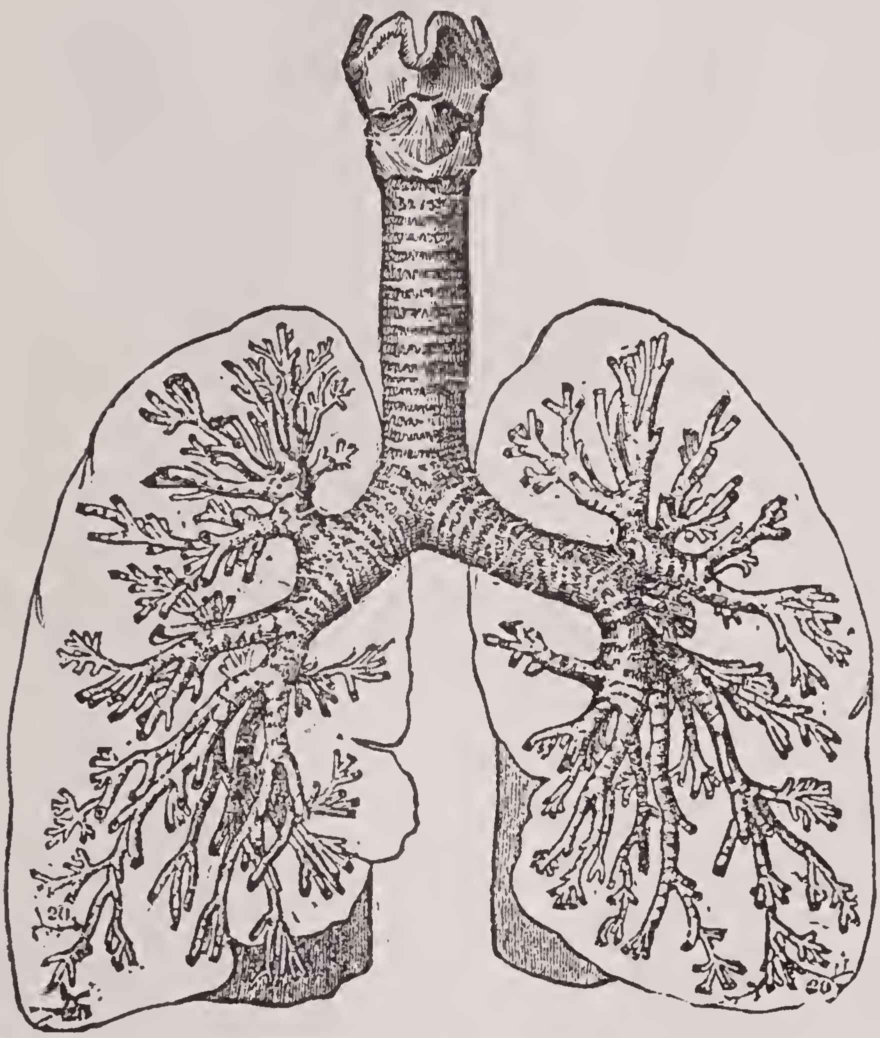


Fig. 112. The Air-Passages.

The *bronchial tubes* are simply continuations of the trachea, which divides into two branches in the chest, one of which enters each lung and there subdivides until the tubes become not more than $\frac{1}{120}$ of an inch in diameter, when they terminate in the air-cells. After the bronchial tubes become so small as $\frac{1}{50}$ of an inch, the cartilage disappears from their walls, so that the small bronchial tubes, or bronchioles, have membranous and muscular walls.

The air-passages are lined throughout with mucous membrane. The epithelium of the windpipe and bronchial tubes is very peculiar, consisting of cone-shaped cells, the large ends of which are covered with delicate hairs. These are kept in constant motion, always waving in the same direction, by which means there is maintained a con-

stant current of mucus in the direction of the mouth. The evident purpose of this arrangement is the protection of the lungs from dust, which will be caught in the stream of mucus and carried to the mouth for expulsion.

The relative position of the several portions of the air-passages is well shown in Fig. 112.

The Lungs.—The real structure of the lungs is seen only by examination with a powerful microscope, which shows the pulmonary tissue to be made up almost wholly of small cells and minute capillary blood-vessels, together with the small bronchial tubes. These several elements are somewhat loosely held together by bands of yellow elastic tissue, of which a great share of the lung substance is composed. The cells are arranged in groups of fifteen or twenty, which are called lobules. Each lobule is attached to the end of a bronchiole with which it communicates. Fig. 113 shows two of the lobules with the end of the small bronchial tube with which they are connected. The number of cells in the lungs has been calculated to be not less than seventeen hundred million (1,700,000,000).

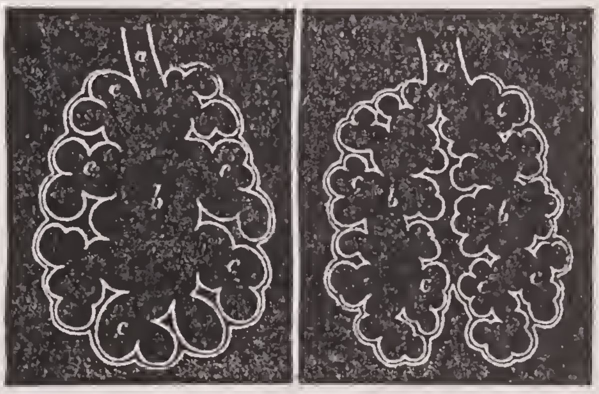


Fig. 113. Lobules of Lung, showing at *a* end of bronchial tubes, and at *c c* air cells.

The lung cells as well as the air-passages are lined with a membrane which is so very thin that twenty-five hundred layers would be required to make an inch in thickness. The extent of this membrane is very great, owing to the great number of the cells. It has been estimated that if spread out its area would be not less than two thousand square feet. Underneath this thin membrane is spread out, in the walls of the cells, the closest network of capillaries in the body. So small are they that only a single blood corpuscle can pass through at once, and so near are they placed together that they occupy fully three-fourths of the entire surface, great as it is. Through these minute channels pass over fifteen barrels of blood every twenty-four hours.

The lungs occupy the two sides of the chest, the cavity of which they nearly fill. The right lung is divided by two deep fissures into three portions, called lobes. The left lung consists of two lobes. Both lungs are covered over with a delicate serous membrane, the *pleura*, which also lines the chest walls.

The *thorax* is the upper of the two cavities into which the trunk of the body is divided, being separated from the abdomen by the diaphragm, a muscular organ which has been already described. It is made up of its bony framework—the ribs, vertebræ, and sternum—and the muscles which lie between the ribs and about the upper part of the chest. It is lined by the same membrane which covers the lungs, the pleura. The lungs lie in immediate contact with its inner walls, but are perfectly free from attachment to it. The thorax contains, in addition to the lungs, the heart and the great blood-vessels, together with important nerves. Connected with the thorax and accessory organs of respiration are several sets of muscles which aid in expanding and contracting the cavity of the thorax.

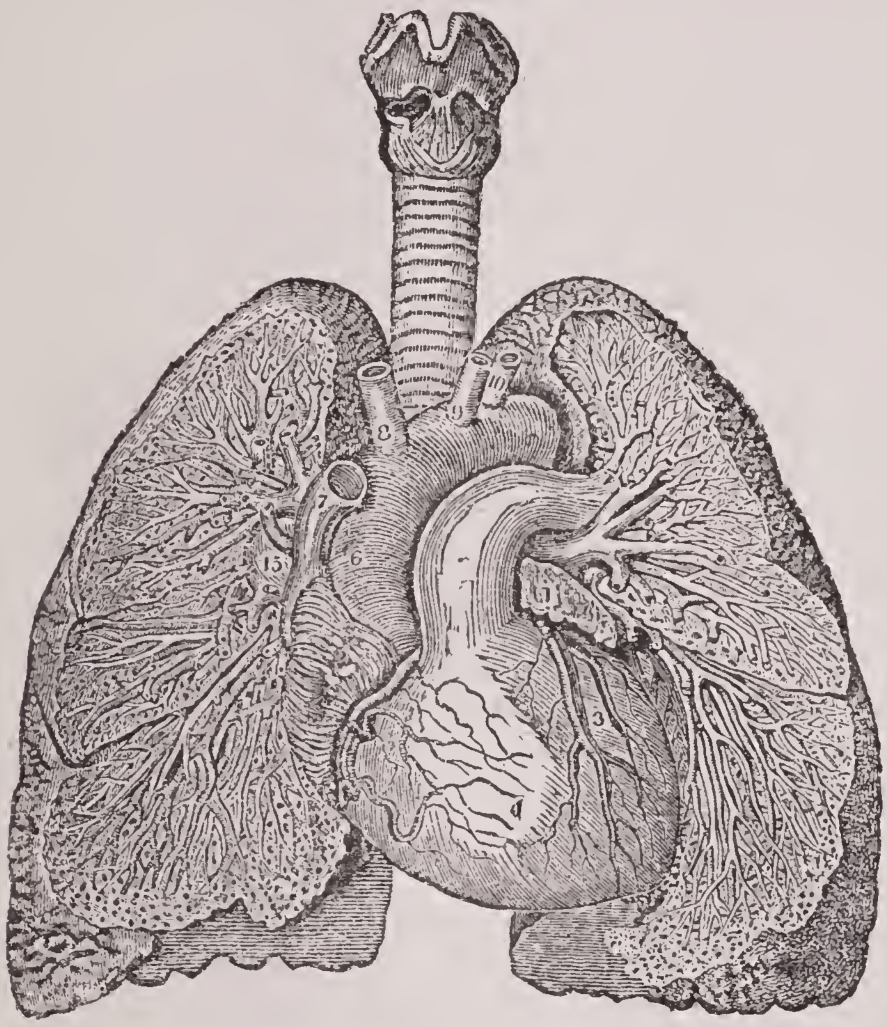


Fig. 114. Cut showing the relation of the Lungs and Heart.

PHYSIOLOGY OF RESPIRATION.

The lungs are the means by which the system receives gaseous food. It is received all ready for use by the system, no elaborate preparation being required as in the case of solid food taken by means of the stomach. Of the three kinds of food received by the body, solid, liquid, and gaseous, air is by far the most immediately essential to life. A person may live many days without solid food, and several days with neither solid nor liquid aliment; but death occurs in a few minutes when the supply of air is cut off, as in suffocation or drowning, a fact which indicates with sufficient clearness the importance of the subject.

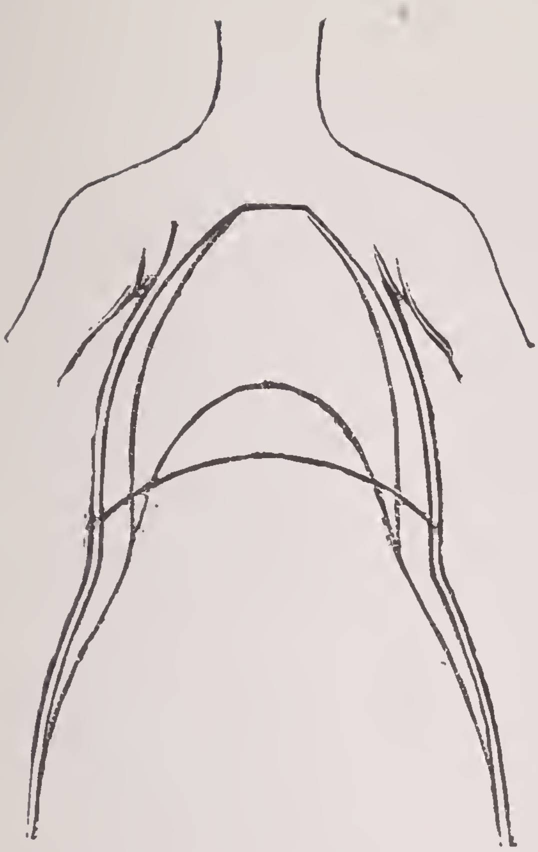


Fig. 115. Cut showing how the capacity of the chest is enlarged by expansion of its walls and depression of the diaphragm.

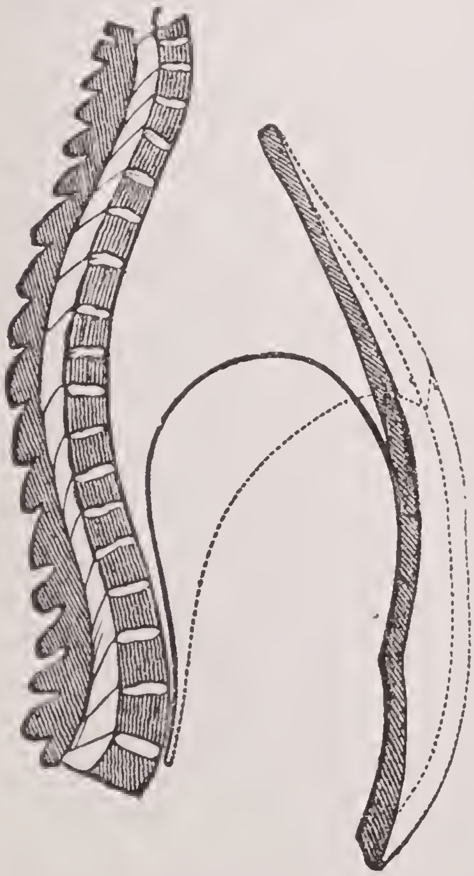


Fig. 116. A lateral view illustrating the same as Fig. 115.

Movements of Respiration.—The acts of respiration are two,—inspiration and expiration. These two acts are performed by changes in the size of the thorax. In producing inspiration, the thorax is made larger, by depression of the diaphragm—which elongates the chest cavity—and elevation of the ribs, which enlarges the chest laterally. In consequence of the increased space in the thorax, the air simply rushes in to occupy the room made for it. It should be noticed in this connection that the air does not force its way in, but simply enters when invited by room being made for it. In expiration, the opposite takes place. The ribs are lowered, and the diaphragm, being relaxed, is pressed upward into the chest by the contraction of the abdominal muscles. The natural elasticity of the lungs also aids in expiration, as they are forcibly distended during inspiration, and naturally tend to return to their normal state, which is undistended, as at birth. There are said to be three kinds of respiration, according to the portion of the lungs which is most active. When the breathing is performed mostly by the diaphragm, it is termed *abdominal* respiration; when the lower portion of the ribs is used, *inferior costal;* and when the upper part of the chest is employed, *superior costal.* The last-named is the most common respiration in women, which is said to be natural for them, but which, in our opinion, is due to the fact that by their mode of dress the lungs are usually confined so that only the diaphragm and upper ribs can operate freely, the

chest being effectually hindered from lateral expansion by the employment of tight-lacing with or without the use of corsets. For change in size and appearance of chest during respiration, see Figs. 115, 116, 117, 118.

Frequency of Respiration.—The general law of respiration requires one respiratory act for every four heart-beats. As the pulse is seventy-two to eighty per minute in the adult, respiration is from eighteen to twenty during the same time. The frequency of respiration is increased and diminished by the same causes which affect the pulse rate. It is notably increased by exercise, heat, and stimulants, and diminished by sleep and by cold. During the hibernation of animals respiration is so slight and infrequent as to be almost imperceptible, the pulse being diminished proportionately.

Coughing, Sneezing, Laughing, and Other Modifications of Respiration.—Most of these modifications of the respiratory act are more or less involuntary, though to some degree controllable by the will. *Coughing* and *sneezing* consist of a prolonged inspiration followed by a forcible exhalation, produced by a convulsive expiratory effort, the air, in coughing, being expelled wholly through the mouth, in sneezing by both mouth and nose, though chiefly by the mouth, contrary to the usual opinion. *Sighing* is a deep and prolonged inspiration, followed by a rapid and audible expiration. A slight sigh naturally occurs every seventh or eighth respiration, by which a more complete change of air in the lungs is effected than in ordinary breathing. *Yawning* is similar to sighing, except that the mouth is widely opened during inspiration and that it is involuntary. It is a curious fact that yawning is contagious in a remarkable degree. A person who is able to imitate yawning well may by adroit management set a whole company of people yawning. *Laughing* and *sobbing* differ more in the character of the emotions which they accompany than in the mode of production. Both acts result from short and convulsive movements of the diaphragm, accompanied by contraction of the muscles of expression. *Hiccough* is a modification of inspiration, being due to sudden contraction of the diaphragm. It is usually indicative of derangement of digestion, being often caused by rapid eating and by the use of effervescing drinks.

Capacity of the Lungs.—The cubic contents of a pair of well developed lungs is about three hundred and twenty cubic inches. Of

this quantity but a small part is used in ordinary respiration, not more than twenty cubic inches. It is possible, however, after making an ordinary expiration of twenty cubic inches, by a strong effort to force out one hundred cubic inches more. It is also possible after an ordinary inspiration to inhale, by a strong effort, one hundred cubic inches extra. Thus after a forcible inhalation a person may expel from the lungs two hundred and twenty cubic inches of air; but there always remains one hundred cubic inches of air in the lungs which cannot be expelled. The object of this great surplus of breathing capacity is to provide for contingencies of various sorts which are continually arising, and which make demands for an increased quantity of air. It is to this that is due the fact that persons may even live for years after one lung has become entirely useless, examples of which we have several times met in our own practice. The comparative capacity of the lungs after inspiration and after expiration is well shown in Figs. 117 and 118.

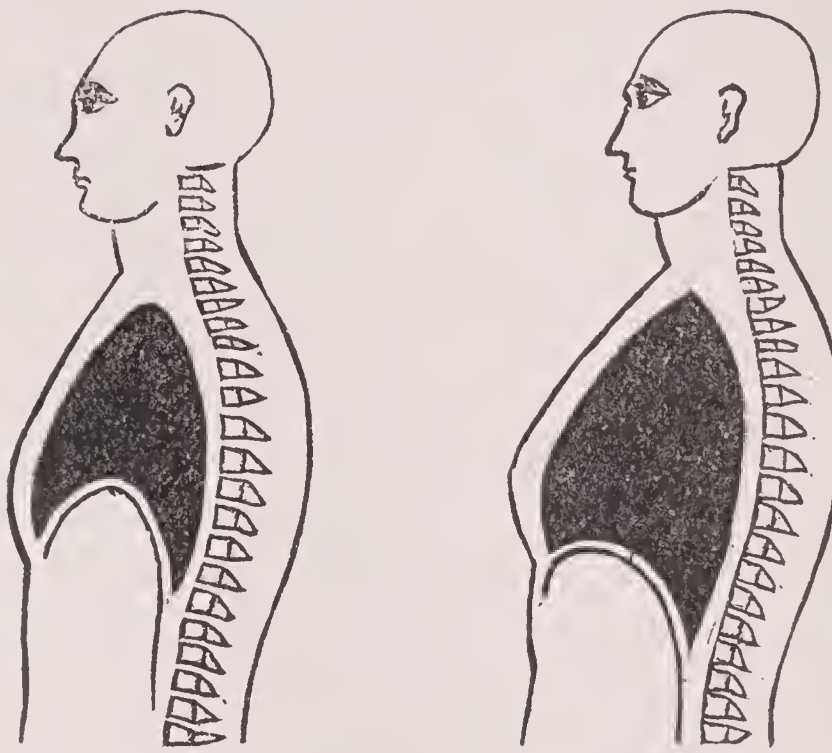


Fig. 117. **Fig. 118.**

FIG. 117. Relative capacity of the Chest and position of the Diaphragm after a complete Expiration.

FIG. 118. Relative capacity of the Chest and position of the Diaphragm after a full Inspiration.

Vital Capacity.—The amount of air that can be changed at one respiration is called the *vital capacity* of an individual. Dr. Hutchinson has shown that vital capacity depends much upon the height, and increases regularly at the rate of eight cubic inches for every inch of increase in height between five and six feet, being about one hundred and seventy-five cubic inches for a person five feet in height, and about two hundred and fifty-five cubic inches in persons six feet in height. The vital capacity can be greatly increased by proper training, as we have often demonstrated in the treatment of consumptive patients.

Composition of the Air.—The air we breathe is a simple mixture of numerous gases, the chief of which are oxygen and nitrogen, the former constituting about one-fifth, and the latter four-fifths of the whole, the other gases being so minute in quantity that they need not be taken into account, with the exception of carbonic acid, or more properly carbon di-oxide, and watery vapor. Of the former the air contains about four parts in ten thousand; and of the latter a variable quantity. That is, in one hundred cubic inches of air there are about twenty cubic inches of oxygen (20.89), and about eighty cubic inches of nitrogen (79.11); and in ten thousand cubic inches of air there are four of carbon di-oxide. Besides these the air contains slight quantities of the various gases given off in animal and vegetable decomposition, and arising from the numerous chemical and physical changes going on upon the surface of the earth, together with dust and various other foreign matters, all of which may be considered impurities, the nature and dangers of which will be elsewhere explained.

For animals, and, in fact, according to recent discoveries, for all living forms, vegetable as well as animal, the oxygen of the air is the essential element. Life is dependent upon its regular and adequate supply more than upon any other element.

The nitrogen of the air is only useful to dilute the oxygen, as in an atmosphere of pure oxygen we should live so fast as to be very short-lived. Experiments with animals show that prolonged inhalation of air in which the proportion of oxygen is much different from that in which it naturally occurs in the atmosphere produces great disturbance of the system and finally death, from which it appears that the mixture which we call air is not an accidental compound, but one admirably adapted to the wants of human beings as well as lower animals and even plants.

The carbonic acid in the air is the result of animal and vegetable decomposition, combustion, and the respiration of plants and animals. It is not necessary to human life, but is essential to the life of plants, of which it constitutes one of the principal forms of food, another admirable adaptation of nature by which what is poisonous to one part of the animate creation is essential to the existence of the other. Plants require carbonic acid, or carbon di-oxide, as food, yet they respire oxygen, as do animals. This fact has not been known until recently.

The watery vapor of the air is necessary to enable the lungs to

utilize the oxygen readily, it being found by experiments that dry oxygen is absorbed much less rapidly than that which contains a due proportion of moisture.

Changes in the Air During Respiration.—Upon examining the air which is exhaled from the lungs it is found that while passing through these organs it undergoes certain changes, both losing and gaining certain elements. The air taken into the lungs in an ordinary respiration—

Loses about one cubic inch of *Oxygen.*
Gains about one cubic inch of *Carbonic Acid Gas.*
Gains about one cubic inch of *Watery Vapor.*
Gains about one cubic inch of *Organic Matter.*

During forced respiration, when a larger quantity of air is inhaled, the quantity of oxygen lost in the lungs and the amount of carbonic acid gained are of course greater, which is also true of the other changes mentioned. It should be remarked that the amount of carbonic acid gained is a little less than that of the oxygen lost.

Changes in the Blood in Respiration.—The changes which occur in the blood while passing through the capillaries of the lungs are equally marked. When the blood enters the lungs from the pulmonary artery, which brings it from the right heart, it is of a dark purple color, its color being due to the impurities which it contains, the chief of which is carbonic acid. When the blood leaves the lungs, it is of a bright red color, having exchanged its carbonic acid for oxygen, which is absorbed by the red corpuscles to be conveyed to every part of the system, being assimilated in the capillaries of the tissues and changed to carbonic acid, which is brought back to the lungs in the venous blood. Other impurities are also given out in the lungs, constituting the organic matter of the expired air. The blood also loses a little of its water in passing through the lungs, and is slightly cooled. The last-mentioned fact completely refutes the old theory of an eminent chemist, which is still believed by some, that the lungs are a sort of furnace in which the carbon of the blood is consumed as coal or wood is consumed in a stove, since if the theory in question were true, the blood would gain heat in the lungs instead of losing.

The blood and air are brought into such close contact in the lungs, being only separated by the delicate membrane already described, which is not more than $\frac{1}{2500}$ of an inch in thickness, that the change

of gases takes place with the greatest facility. Indeed, it is believed that the membrane lining the air-cells facilitates, rather than hinders, the escape of the carbonic acid in the lungs and the absorption of oxygen. When it is considered that nearly five hundred gallons of blood are thus purified every day (the same blood being purified over many times), for which more than eighty barrels of air are required, it is readily seen that there is abundant necessity for the two thousand square feet of membrane devoted to this purpose in the lungs.

By this process of indirect combustion, in many respects analogous to the burning of coal on a grate or of wood in a stove, or the burning of a candle or a gas jet, more than half a pound of solid carbon is daily consumed in the body. In persons whose occupation is very laborious, more than three-quarters of a pound is thus daily consumed.

The amount of carbonic acid exhaled is modified by several other influences besides exercise, as age, sex, diet, etc. The largest amount is exhaled during the prime of life, gradually increasing from infancy to that period, and declining during advancing age. Females exhale much less than males. Much more is produced during digestion than at other times, the amount being particularly increased by certain articles of food, as sugar and animal food, and especially by stimulants, wine, rum, beer, ale, cider, and even tea and coffee, a fact which completely refutes the argument made in favor of the last-named articles, that they diminish the waste of tissue, since it is evident that they increase it. These facts were chiefly established by the experiments of the late Dr. Edward Smith, of England. During sleep the amount of carbonic acid exhaled is greatly diminished. In the winter sleep of some hibernating animals it is reduced to less than $\frac{1}{30}$ of the ordinary amount. Violent exercise may increase the quantity of carbonic acid exhaled to six times the ordinary amount. In a dry atmosphere the mucous membrane of the lungs becomes dry, and thus loses in a considerable degree its power to transmit gases, so that the amount of carbonic acid is greatly diminished while breathing it.

Respiration of the Skin.—The lungs are not the only respiratory organs. The skin also participates in the process, though it does but a small amount compared with the lungs, the proportion being not more than one to forty. In some lower animals, as in the frog, a much larger amount of respiratory work is done by the skin.

HYGIENE OF RESPIRATION.

Under this head we shall dwell specially on such portions of the subject as pertain particularly to the lungs, leaving the hygiene of the air and the subject of ventilation for more complete and explicit consideration in a separate chapter.

Lung Exercise.—No part of the body is susceptible to greater improvement from systematic exercise, or suffers greater detriment from neglect of exercise. When the lungs are not well expanded habitually, they gradually lose, to some degree, their elasticity, so that the power to expand them is lost. In the physical examination of hundreds of chests we have had occasion to notice, in scores of instances, the almost total loss of power to expand the chest. If asked to do so, the patient would shrug his shoulders, perhaps elevate them as high as possible, and make a desperate attempt to get a little more air than usual into his lungs, accomplishing but very little in that direction, however, as the tape-line placed about the chest showed no appreciable increase in size. We have often found persons in this condition, whose chests ought to have measured two to four inches more when filled than after inspiration.

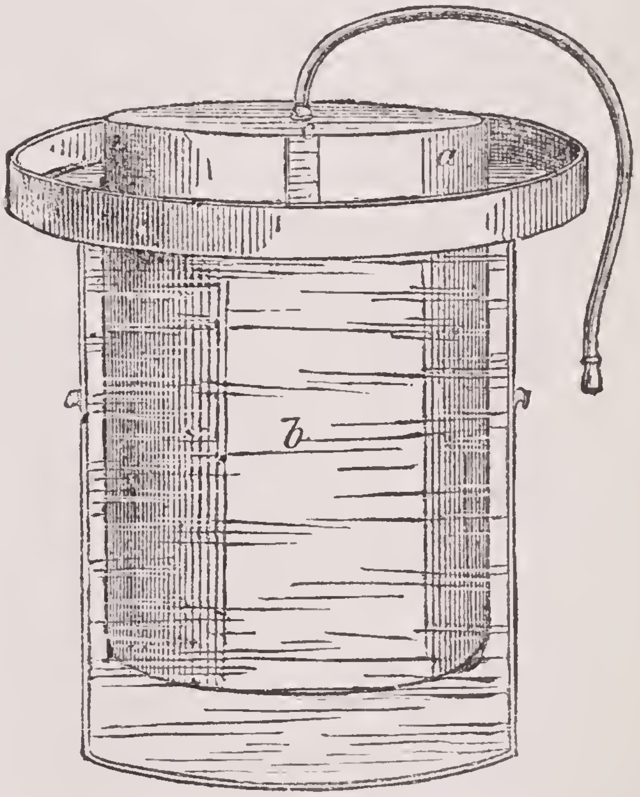


Fig. 119. Spirometer. *a.* Inner vessel, with which the inhaling tube communicates; *b.* Outer vessel containing water; *c.* Scale indicating the number of cubic inches inhaled.

The Spirometer.—The use of the spirometer is an excellent means of noting the change which can be made in the vital capacity of the lungs by systematic exercise persevered in daily for months. This instrument is shown in Fig. 119. As it is very simple, it can be made by any tinsmith at an expense of a few shillings. The instrument consists of two tin vessels, one inverted inside the other. The larger one should be nearly filled with water, and should have a small tube passing up through the center nearly to the top. This should communicate with a flexible tube outside, to the end of which is at-

tached a mouth-piece which may consist of a short glass tube with a good-sized bore. By blowing into the tube the inner vessel will be made to rise, and the amount of air expelled will be indicated by a scale accurately determined by previous calculation or experiment, and marked on the outside. If the inner vessel is eight inches in diameter, a scale may be made with lines one-tenth of an inch apart, each of which will represent five cubic inches of air. A person five feet high ought to be able to raise the scale three inches and a half after taking a full inspiration. A person six feet high should be able to raise it five inches.

By the daily practice of lung gymnastics as described in the chapter on exercises, a person may increase his vital capacity from a few inches to many times as much.

When a person is weary, and feels exhausted from sedentary employment, the practice of deep and prolonged respiration with the chest well expanded, the shoulders back, and the spine erect, will be exceedingly refreshing.

The great advantage of abundance of lung exercise is well seen in the fact that professional singers suffer less from pulmonary difficulties than others. A medical professor of St. Petersburg recently examined the chests of more than two hundred professional singers in that city, and found their chests better developed than those of the majority of persons, and an almost entire absence of lung diseases.

Corset Choking.—Choking is keeping air out of the lungs; at least, that is a practical definition of the word. It makes no difference to the lungs and no difference to the blood, whether the life-giving oxygen is kept out by confining the respiratory apparatus at its lower or its upper part. The result is precisely the same in either case. A man who ties a rope around his neck and kills himself by choking is called a suicide. A young lady who does essentially the same thing by lacing her waist, only taking a little longer time for it, is considered extremely fashionable. Pure air is the first and the last desideratum of human life. Independent life begins with the first breath, and ends with the last act of respiration. A human being lives in proportion as he breathes. Frogs and lizards are sluggish because they breathe little. Birds are more vigorous in their movements because of the wondrous capacity and activity of their lungs. So with human beings. Need we suggest that those feeble-minded creatures who emulate each other in compression of the waist—thus curtailing the breathing power—are like frogs and lizards

in their capacity for appreciating the "joy of living"? or that their organs of cerebration may be as diminutive as their waists?

The evils of corset-wearing have already been dwelt upon quite fully, and we will not recapitulate here; but we wish to call special attention to three ways in which the use of corsets, whether worn extremely tight or not, acts injuriously upon the lungs and respiration.

1. By compression, the muscles of respiration lose their power to act, and waste away, so that strong, deep respirations become impossible. This is the reason why ladies feel, when deprived of their corsets, as though they would "fall all in pieces."

2. By confinement in a stiff, unyielding case, the elastic cartilages which unite the ends of the ribs to the breast-bone so as to give freedom of action become rigid, and thus prevent full expansion of the chest and filling of the lungs.

3. By compression of the lower part of the lung the upper part is crowded up against the inner border of the first rib, against which it is continually pressed, so that the constant motion and friction finally excite irritation which undoubtedly becomes the starting-point of many cases of consumption.

Poisonous Character of Air Which Has Been Breathed.—As already shown, air which has been breathed contains a large proportion of carbonic acid, and besides this a poison much more deadly in its character, organic matter, the exact nature of which chemists have never yet been able to determine. The carbonic acid is not itself greatly injurious in the quantities in which it is produced by breathing, but as it is always in about the same proportion to the organic matter, it is a reliable index to the amount of the latter poison, and so to the character of the air. It is the organic matter referred to which gives to close rooms the peculiar *fusty* odor with which every one is familiar. Persons who are confined in-doors most of the time become so accustomed to this warning of danger that they do not appreciate it, and hence do not heed it; but when a person who has been some time in the open air comes into a poorly ventilated room occupied by several persons, the odor is very perceptible, and the first impulse is to open the doors and windows and let the foul air out and pure air in, though the persons in the room may be wholly unconscious of the condition of things. This foul and pernicious poison is closely associated with the watery vapor of the expired air. In cold weather this vapor condenses upon the window-panes, and may be collected. The fluid thus collected forms a most fetid

and disgusting mass after standing in an uncorked bottle for a few days.

The experiments and researches of eminent scientists on the nature and effects of this poison as it exists in respired air seem to show quite conclusively that it is the principal cause of the numerous evil effects of breathing air which has been previously respired.

Rapidity with which the Air is Contaminated by Breathing.—Experiments have shown that air which has been breathed over a few times contains ten per cent of carbonic acid, and of course a correspondingly large proportion of the organic poison, which is an increase from four parts in ten thousand of air, to one thousand parts in the same amount of air. According to the results which have been obtained by Parkes, Cameron, and numerous other investigators in this line of sanitary science, a single breath, containing a cubic inch of carbon di-oxide renders unfit for respiration three cubic feet of air. It may be easily calculated from this, with the fact that we usually respire twenty times a minute, how long the air in a seven-by-nine bedroom may be made to last. Supposing such a room to be eight feet high and tightly closed, with one occupant in it, the air would remain fit to breathe less than ten minutes! If bedrooms were air-tight, thousands more would have died from neglect or ignorance of this fact than have already filled premature graves in consequence. Fortunately for the human race, at least for the civilized part of it, our houses are seldom air-tight. A little air will find its way in, even through brick walls. Nature has provided us with an ample abundance of the greatest necessary of life, making it free to all, —for no despot ever put a tax upon the air his subjects breathed,—and even urging us to accept whether we desire it or not.

The Effects of Breathing Impure Air.—Without going into details these may be briefly summed up to be headache, dullness, nervousness, debility, consumption, and an aggravation of all other maladies. The headache of which school-children suffer so much is chiefly due to foul air. Consumption is well known to be most frequent in those whose habits or vocations are chiefly sedentary, or which keep them in a foul atmosphere.

Experience in the late war showed that impure air was an important cause of rendering diseases fatal which otherwise would have been far less serious. At the first Sanitary Convention in this country, held at Detroit, Jan. 7 and 8, 1880, under the auspices of the State Board of Health of Michigan, in the discussion of a paper on ventilation, an old army surgeon who had charge of large hospitals during the war, related a very

interesting experience illustrating the importance of securing to the sick, and especially to persons suffering with fever, an abundance of pure air. He stated that during the war he had charge of a large hospital in which at one time in the winter season he had under treatment three hundred and twenty cases of measles. Just at this time the hospital took fire and burned to the ground. The patients were placed in tents, and all but one or two recovered. He had no doubt that the number of deaths would have been thirty or forty, at least, had the patients remained in the hospital. He afterward sent one hundred men who were only slightly ill to the general hospital at Nashville, and seventy-five of them died. Upon visiting the hospital, he found it so poorly ventilated that the air was exceedingly foul, producing a sickening sensation when he had only been in it for a few minutes. The Doctor concluded by remarking that he regarded pure air and water as most important agents, and believed them to be capable of controlling the ravages of raging disease.

The best methods of receiving an abundance of pure air by ventilation, the amount necessary for each individual, and other questions of importance pertaining to this subject are considered in another chapter.

THE DIGESTIVE APPARATUS.

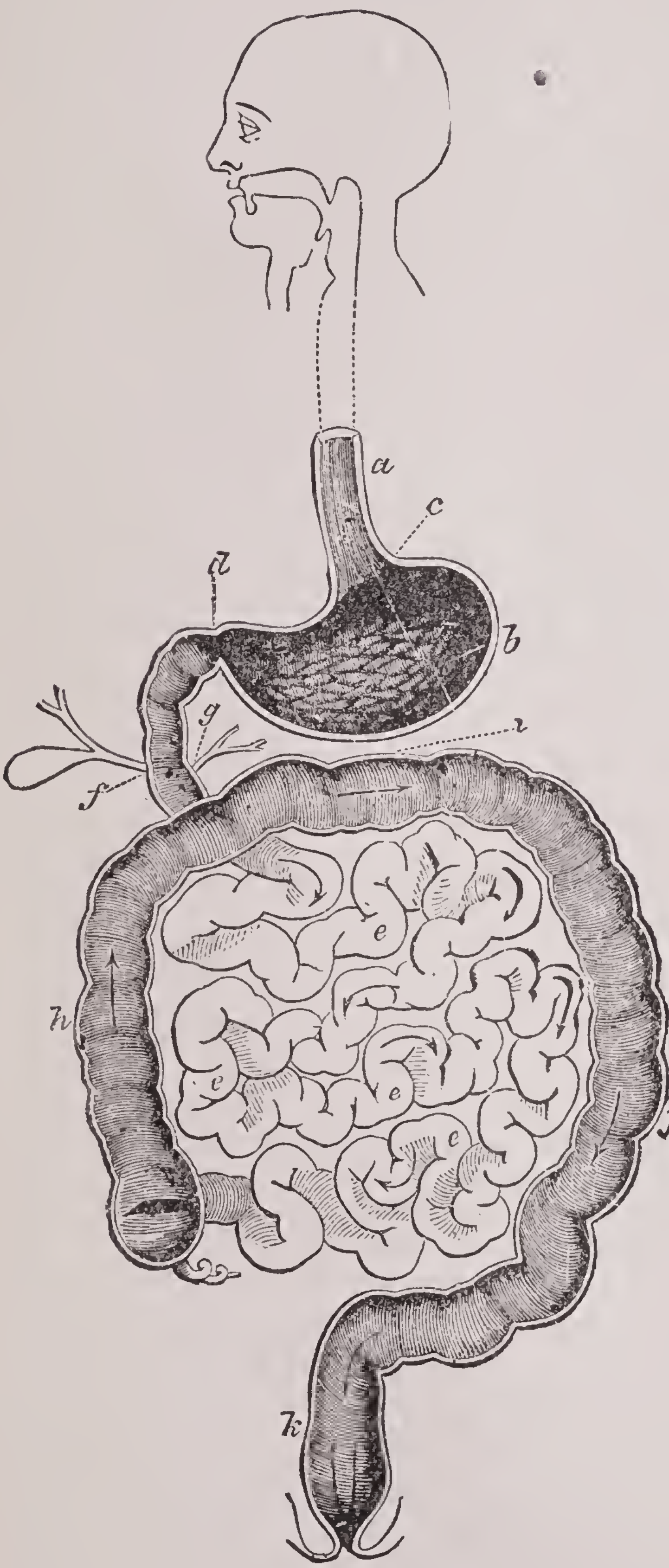


Fig. 120. The Alimentary Canal. *a.* Œsophagus; *b.* Stomach; *c.* Cardiac Orifice; *d.* Pylorus; *e.* Small Intestine; *f.* Bile Duct; *g.* Pancreatic Duct; *h.* Ascending Colon; *i.* Transverse Colon; *j.* Descending Colon; *k.* Rectum.

The Alimentary Canal.—Fig. 120. The digestive apparatus consists of a long, tortuous tube, the *digestive* or *alimentary canal,* to which are appended various accessory organs.

The alimentary canal is about thirty feet in length, and is lined throughout with mucous membrane, which is variously modified, according to its location. Each end of the canal is guarded by a circular muscle, the upper opening, the mouth, being by this means opened or closed at pleasure, while the lower is involuntary in its action, only opening when overcome by force applied from above, a wise provision of nature to antagonize the influence of gravitation upon the contents of the bowels, and to retain the same during sleep or other periods of unconsciousness. This canal, which at an early period of development in human beings—as permanently in some simple animal forms—is merely a straight tube, in the fully developed individual becomes so modified as to present at least five distinct portions, each of which possesses peculiar and important functions, and

hence requires separate description, together with the several accessory organs which are connected with them. Although a more detailed classification is possible, for our purpose it will be sufficient to consider the alimentary tube as divided into the *mouth, œsophagus, stomach, small intestine,* and *large intestine,* or *colon.*

The Mouth.—The mouth, the upper portion of the canal, guarded by the circular muscle of the lips, contains the teeth and tongue, and presents in its mucous membrane the orifices of the ducts of three pairs of secreting organs, known as the *salivary glands.* The back part of the mouth, usually known as the *pharynx,* communicates through the posterior nares with the nasal cavity; through the Eustachian canals, with the ears; through the upper end of the *larynx,* with the lungs: and through another opening at its extreme back part, with the stomach, by means of a canal known as the *œsophagus.* See Fig. 121.

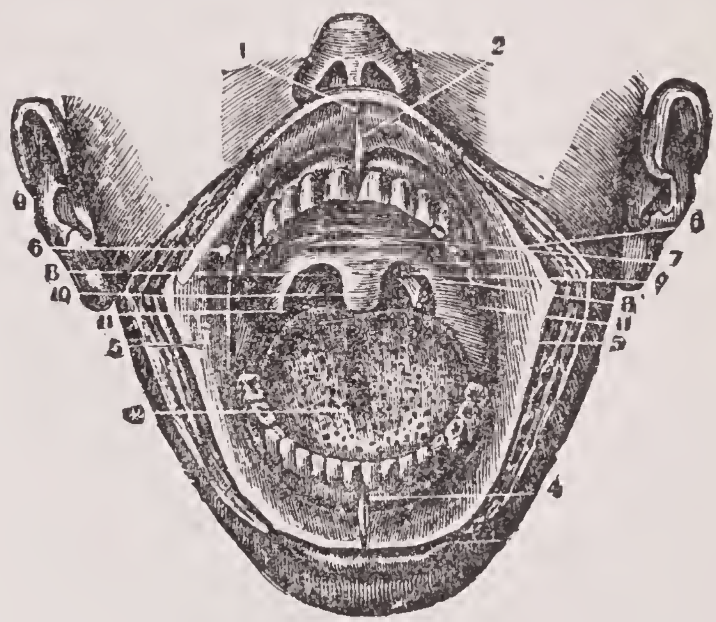


Fig. 121. The Mouth. 6. Mouth of duct from the Parotid Gland; 7. Roof of mouth; 8. Posterior Nares; 9. Fauces; 10. Uvula; 11. Tonsils; 13. Tongue.

The Teeth.—Each tooth has three parts, a *crown,* a *root,* or *fang,* and a *neck.* The crown is the part which appears above the gum. It is covered with a hard, dense substance, the hardest in the body, the *enamel,* which is in turn protected by a very thin covering not more than $\frac{1}{30000}$ of an inch in thickness, the object of which is to protect the enamel from the action of acids. The enamel prevents wear of the teeth in chewing hard substances. Its density varies much in different persons, often becoming soft in consequence of disease. The interior of the tooth presents a cavity which is filled by what is termed the pulp, which is made up of delicate blood-vessels and nerves entering the tooth through an opening for the purpose in one or more of the roots. The hard part of the tooth is chiefly made up of a bony substance called *dentine,* which is identical with ivory. The smaller teeth have but one fang, the larger two, or even three. The neck is simply the slight constriction between the crown and root.

The Milk Teeth.—Two sets of teeth are furnished most persons, some being so fortunate as to acquire a third in advanced age. The first set, called temporary or milk teeth, are twenty in number, ten in each jaw, consisting of four incisors, two cuspids,—sometimes called canine teeth, also eye-teeth in the upper jaw, and stomach-teeth in the lower,—and four molars, or double teeth. These are developed in the following order between the ages of seven months and two years: At seven months, the two central incisors, or front teeth; at eight months, the other two incisors; at one year, the first molars; at one year and a half, the cuspids; at two years, the second molars. See Fig. 122.

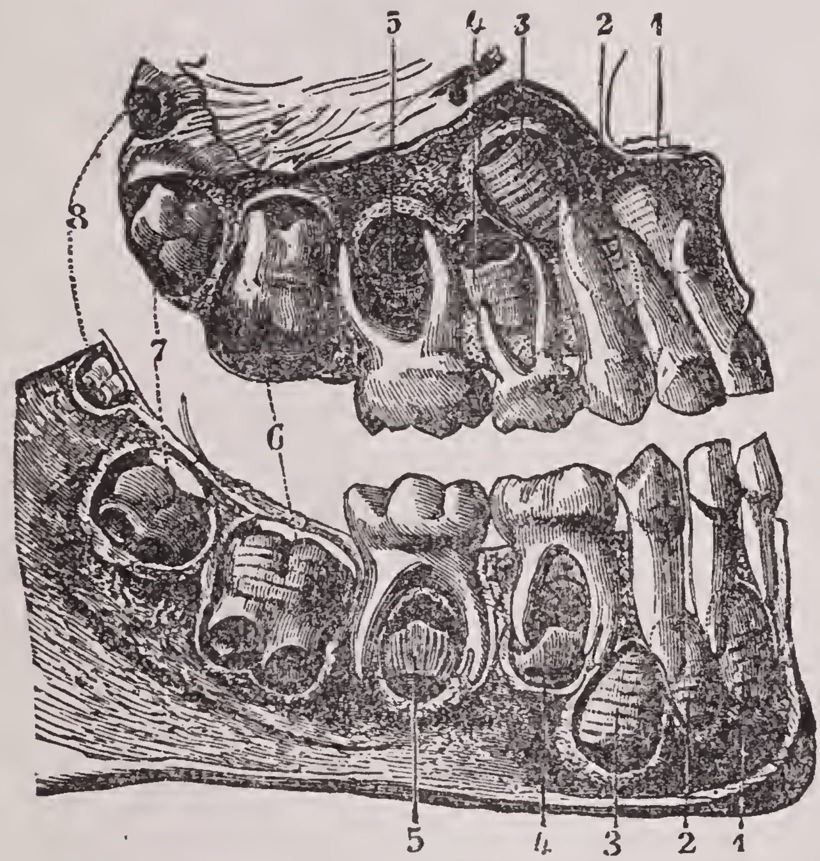


Fig. 122. The Temporary or Milk Teeth. The cut shows at 1, 2, 3, 4, 5, 6, 7, and 8 the rudiments of the Permanent Teeth.

The Permanent Teeth.—Between six and seven years the permanent teeth, which number thirty-two in all, sixteen in each jaw, begin to appear. The permanent teeth comprise the same teeth as the temporary, with four small molars and two large ones in each jaw in addition. See Fig. 123. The first permanent teeth which appear are the first of the large molars, which come just back of the temporary molars, at about six and one-half years. At seven the central incisors are thrown off. The other incisors disappear the eighth year. In the ninth and tenth years the temporary molars give place to the permanent small molars. At twelve the cuspids are changed. During the thirteenth year the second large molars appear; between the seventeenth and twenty-first years the set is made complete by the appearance of the third large molars, or wisdom-teeth. The latter teeth are apt to decay early. The teeth in the lower jaw are generally developed somewhat earlier than those of the upper jaw. The roots of the first set of teeth are absorbed, and probably help to form the second set.

It is important that mothers should be familiar with the proper

time for development of the several teeth, especially those of the first set, as many of the maladies of children are connected with "teething," and may often be prevented by proper attention to the teeth.

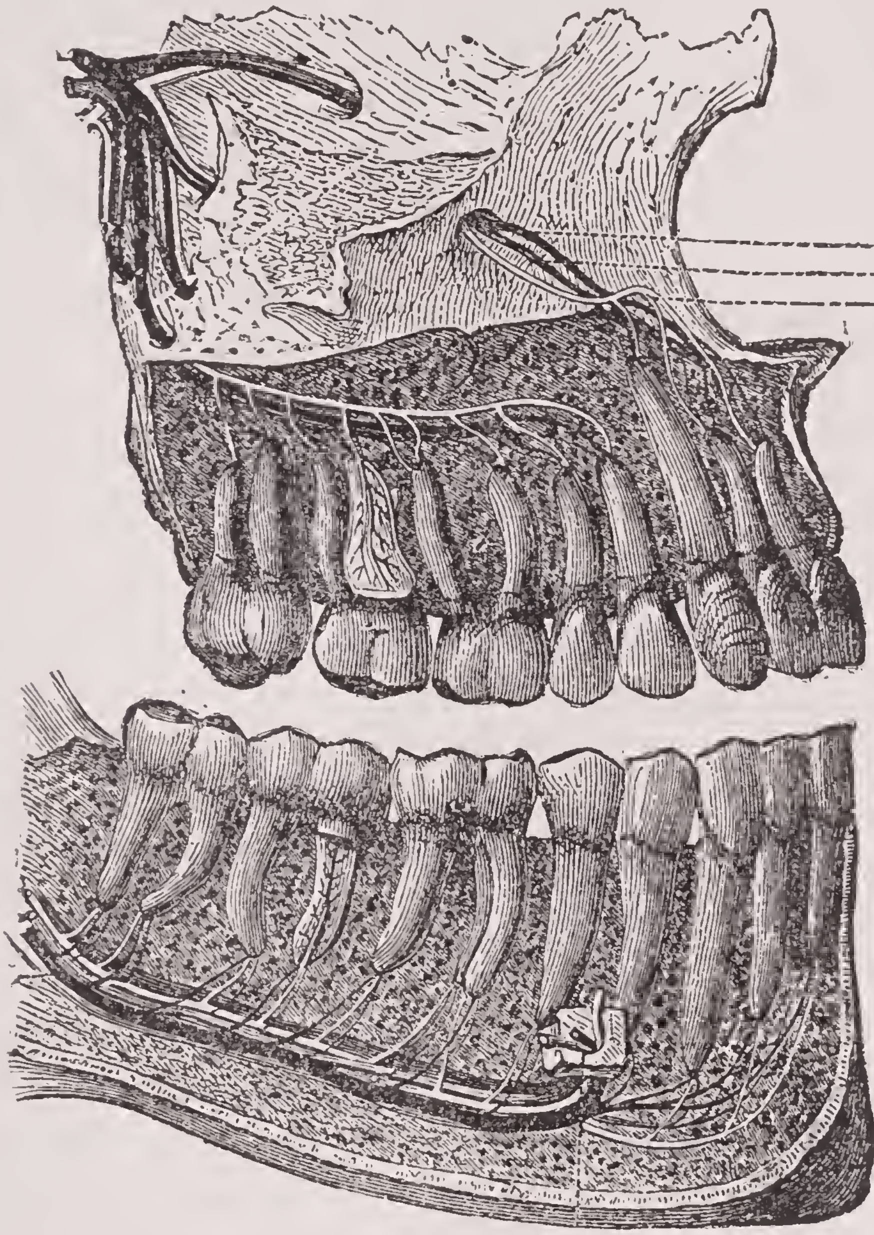


Fig. 123. The Permanent Teeth. The cut shows how each tooth is supplied with nerves and blood-vessels from the same nerve trunks and arteries which supply other parts of the face.

The Œsophagus.—This organ, commonly called the gullet, or meat-pipe, is a muscular canal about nine inches in length, extending from the back part of the mouth to the left upper portion of the stomach. Its walls contain two layers of muscular fibres, the outer layer running longitudinally, or lengthwise of the tube, the fibres of the other being circular in arrangement. When not in use, the walls of the œsophagus lie in contact, so that there is no opening. At the lower end, the circular fibres are sufficiently thickened to form a sphincter muscle, by means of which the contents of the stomach are prevented from escaping upward.

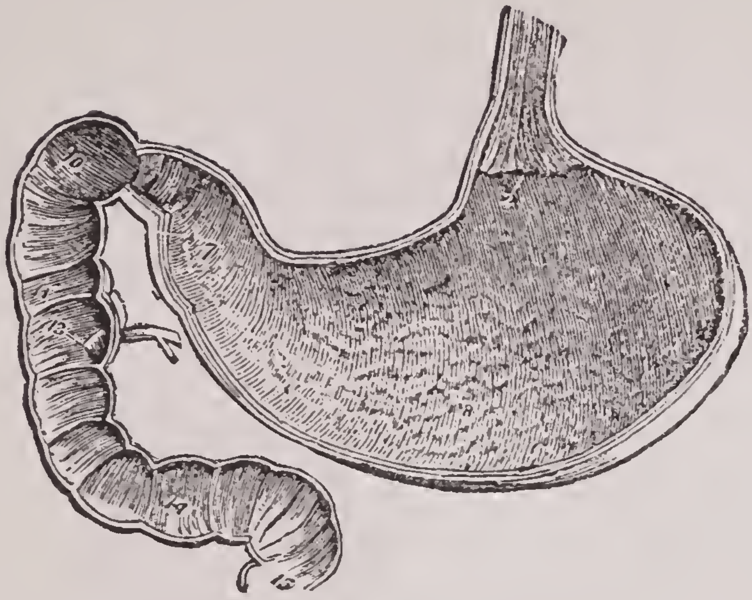


Fig. 124. The Stomach, with a portion of the Duodenum attached.

The Stomach.—This, though one of the most important, is by no means the essential organ of digestion, as was formerly supposed. Contrary to the old view, it is now understood that the stomach is only one of a series of organs which take part in the work of digestion, each of which has an important function to perform, as necessary in its place as that of any other.

The stomach may be briefly described as a hollow muscle. It is simply an expansion of the alimentary canal, which in the œsophagus is reduced to a narrow tube, but at the lower extremity of that organ abruptly expands into a pear-shaped viscus nine to twelve inches in length, and four to five inches in width, in its broadest part. It is capable of holding one to two quarts, but it will allow of considerable distension, so as to be made to hold much more than this quantity.

In early infancy, the stomach is a mere spindle-shaped expansion of the digestive tube; but as the individual advances in age, it becomes more irregular in shape, its lower border being convex, while its upper is concave in outline, as may be seen by reference to Fig. 124.

The walls of the stomach are made up of the outer serous coat, next to which is the muscular coat, made up of three distinct layers, the outer of which, like that of the œsophagus and of the whole alimentary canal, is longitudinal, the next inner layer being made up of circular fibres, and, in addition, still another set of fibres peculiar to the stomach, running in an oblique direction. Within the muscular coat, and lining the organ, is the mucous membrane, which, in addition to the usual characteristics of a mucous membrane, presents peculiar glandular structures, which have received the name of *peptic* glands, from the character of their secretion. These glands are tubular in structure, and are found in all parts of the stomach, but most abundantly in the left, or cardiac end of the stomach, the whole number being estimated at five millions.

Besides its peculiar glands, the gastric mucous membrane contains a remarkable arrangement of blood and lymphatic vessels designed to produce rapid absorption of liquids received into the stomach or prepared for absorption by the process of digestion. Covering the mucous membrane of the stomach everywhere, and lining its tubular glands, is a layer of living cells, known as epithelial cells, or epithelium. It is to these living, active molecules of life that the vital functions of this organ are chiefly due. By them are formed both the mucus which protects the surface of its delicate membranous lining, and the gastric juice for the solution of the food in gastric digestion. The epithelium itself also protects the membrane upon which it rests.

At the lower end of the stomach is a narrow orifice at which the circular muscular fibres are much thickened, forming a sphincter muscle; this is known as the *pylorus*, which literally signifies, "gate-keeper." The relative position of the stomach and of the other digestive organs may be readily seen by reference to PLATE VII.

The Small Intestine.—The pylorus forms the division between the stomach and the small intestine, which constitutes by far the greater portion of the alimentary canal, being about twenty feet in length. Its convoluted form, as seen in the diagram already referred to, is necessitated by its great length, which, together with the several functions which it performs, makes it by far the most important of the different portions of the digestive apparatus. See Fig. 120.

That portion of the small intestine joining the stomach is called the *duodenum*, which is about ten inches in length, and broader than the rest of the small intestine. In structure, the small intestine has the same general plan as that observed in the stomach; viz., an external serous coat, the *peritoneum*, then the longitudinal and circular muscular layers, and an inner lining of mucous membrane with its glands and epithelium. The mucous membrane of the small intestine presents a variety of glands, together with peculiar and remarkably well adapted structures for increasing the rapidity of absorption, known as villi. Figs. 125, 126, and 127.

The Liver and Pancreas.—Fig. 128. In close proximity to the duodenal portion of the small intestine are two large glands, the liver and the pancreas, each of which communicates with the intestine by a duct, the two ducts having a common orifice in the mucous membrane of the duodenum, a little more than five inches below the stomach.

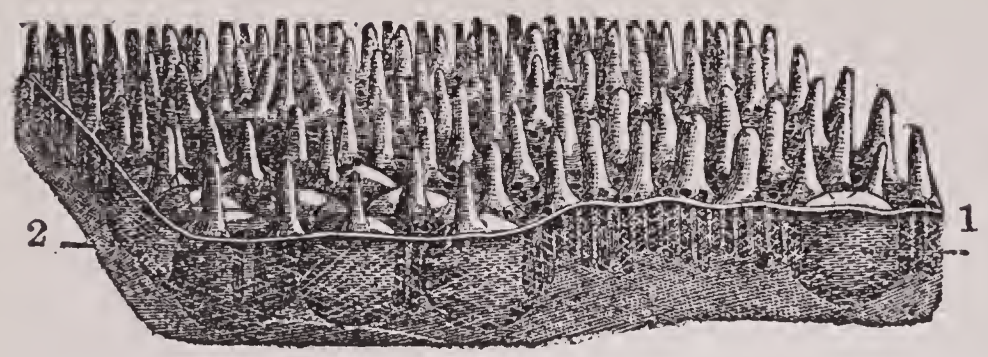


Fig. 125. Villi of intestines slightly magnified. 1. A Solitary Gland; 2. Agminated or Clustered Gland.

The Colon.—At its lower extremity, the small intestine communicates with a greatly expanded portion of the alimentary canal, called the *colon*. The point of junction between these two portions is upon the right side, near the groin, and is guarded by a peculiar structure of the mucous membrane known as the *ileo-cœcal* valve. The colon is about five feet in length. It consists of the ascending, transverse, and descending portions, the last-named part having at its

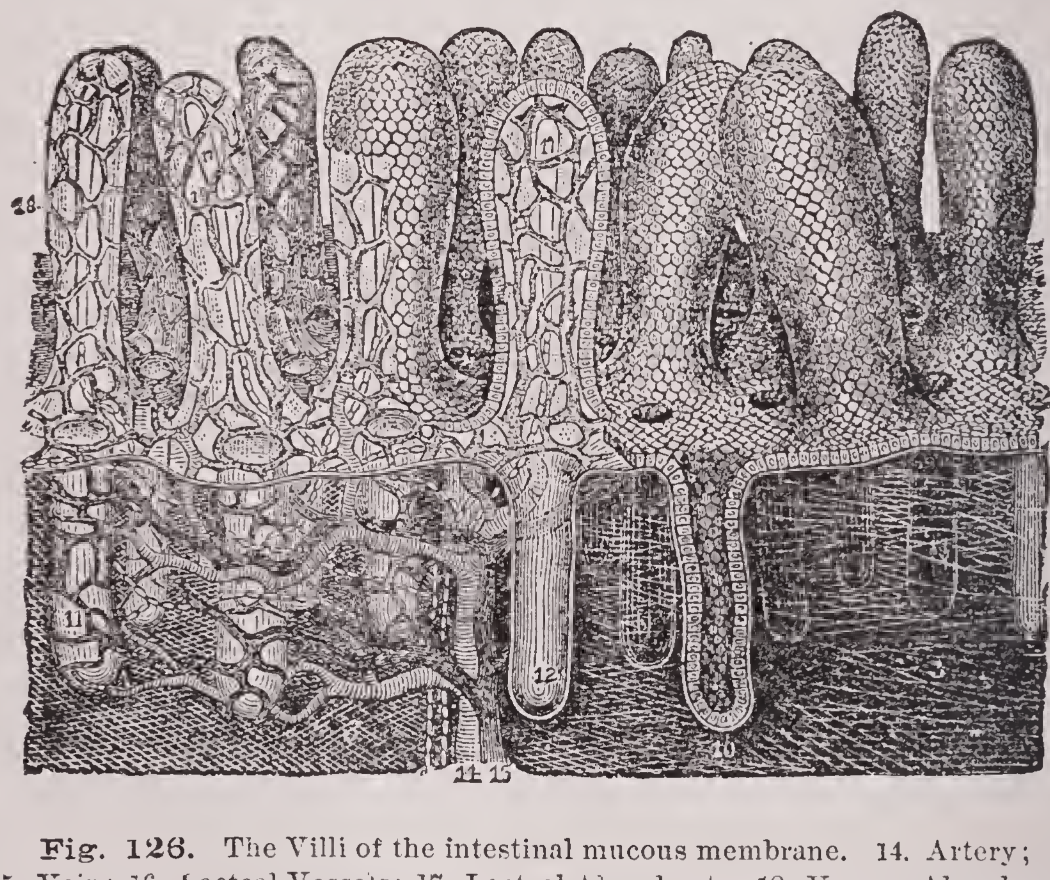


Fig. 126. The Villi of the intestinal mucous membrane. 14. Artery; 15. Vein; 16. Lacteal Vessels; 17. Lacteal Absorbents; 18. Venous Absorbents.

lower extremity the *rectum*. The peculiar structure of the colon is such as to well fit it for completing the process of digestion. Like the stomach and the small intestine, the colon has also its muscular and mucous coats, the latter containing various glands, most of which are excretory in character. The position of the colon and of its several portions will be readily seen by reference to PLATE VIII.

The Digestive Juices.—The apparatus of digestion thus far described is chiefly mechanical in its operation, serving to comminute

and transport the food. In some animals, as in some species of birds, this is the most essential part of the work of the stomach. In man and most animals, another class of agents is required; viz., a variety of fluids capable of reducing to a soluble and liquid condition the several elements of food, thus preparing them for absorption. We find these several fluids produced in the human digestive apparatus at the several points where they can accomplish the work required of them in the most efficient manner. They are five in number, and may be briefly described as follows:—

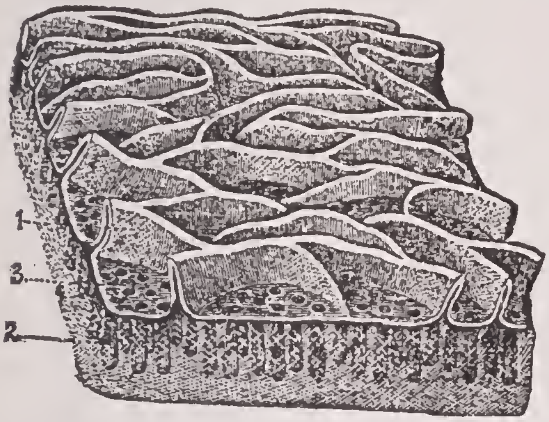


Fig. 127. 1. Folds of the intestinal mucous membrane; 2. Tubular Glands; 3. Mouths of the tubular glands.

The Saliva.—The first of the digestive fluids is formed by the three pairs of salivary glands located in the vicinity of the mouth and connected with it by a system of ducts, through which the salivary fluid is conducted into its cavity. As found in the mouth, the saliva is a mixed secretion, containing, in addition to the products of the three pairs of glands, mucus from the membrane lining the oral cavity. It is a clear, limpid fluid, slightly alkaline in character, and is produced in abundance by frugivorous and herbivorous animals. Carnivorous animals produce it in scanty quantity, having little need for it, as their food rarely contains the particular elements which the saliva is designed to aid in digesting. The quantity of saliva secreted by the human salivary glands is about three pints in twenty-four hours, of which about one-half is formed during digestion.

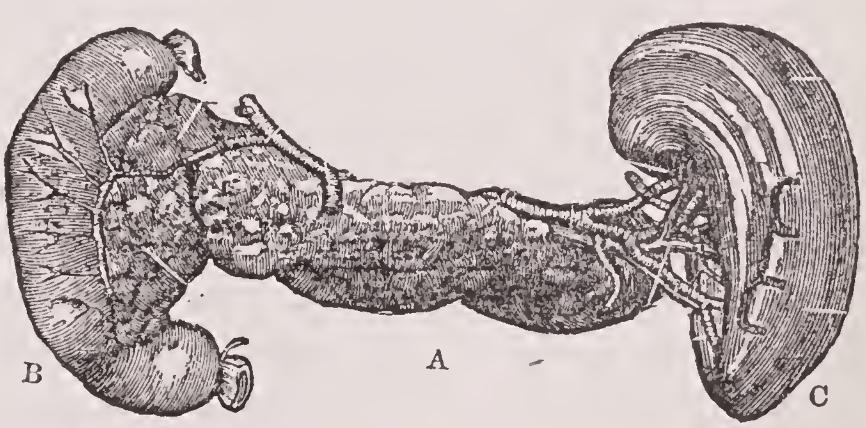


Fig. 128. A. Pancreas; B. Duodenum; C. Spleen.

The Gastric Juice.—This is an acid fluid formed only during digestion, by the peptic glands of the stomach. It is produced in great abundance, amounting, in twenty-four hours, to twelve or fourteen pints. Its activity as a digestive agent is due to a peculiar

principle which it contains, known as *pepsin*, which can be readily separated from the gastric juice, and can be extracted from the mucous membrane of the stomach after death. Large quantities of pepsin are manufactured in this way from the stomach of the hog. One firm with which we are acquainted employs for this purpose over three hundred hog stomachs daily. A similar principle is extracted from the lining membrane of the gizzard of fowls; and an enterprising foreigner has recently utilized the stomach of the ostrich for the same purpose.

The acidity of the gastric juice seems to be a condition necessary for the efficiency of pepsin, its active principle; but physiologists have not yet been able to determine the exact nature of the acid to which this property is due. It is most probable that pepsin itself, when existing in its normal organic combination, possesses acid properties.

The Pancreatic Juice.—This fluid, which so nearly resembles the saliva that it was once called "abdominal saliva," is the product of the pancreatic gland, which resembles the principal salivary glands in structure as closely as does its secretion the salivary secretion. This fluid is secreted only during digestion, and is then produced in considerable quantity, although the amount formed in twenty-four hours, or the quantity necessary for the digestion of a given amount of food, has not been ascertained. Like the saliva, the pancreatic juice is alkaline in character, and has an important office to perform in the digestion of certain of the elements of food.

The Bile.—This fluid, usually considered an excretion, also seems to possess certain useful properties as a digestive agent. It is strongly alkaline, of a greenish color and bitter taste, and is produced most abundantly during digestion, although its secretion continues in limited degree during the intervals of digestion. This fact well accords with the compound nature of the fluid, it being both a secretion and an excretion, the latter function evidently requiring continuous activity, while as a secretion its activity is demanded only at intervals.

The bile, in company with the pancreatic juice, enters the duodenum at a point about five inches below the stomach, so that, contrary to the old views of digestion, the bile is found in the stomach only under very exceptional circumstances.

The Intestinal Juice.—This, the most complicated of all the digestive juices, is the product of the activity of the numerous and

varied glands found in the mucous membrane of the intestines. Being a mixture of the secretion of a number of different glands, the intestinal fluid is of a compound character, which well fits it for its varied functions, as will be seen when we come to consider the physiology of digestion.

THE PHYSIOLOGY OF DIGESTION.

The Chemistry of Digestion.—While the numerous and really remarkable changes which take place in digestion are by no means chemical in character, in the sense in which the word is generally understood, yet we may allow the term if we understand that by it is meant, in this connection, not the reactions which take place in dead matter in obedience to the laws of chemical affinity, and which the chemist can command at will in his laboratory, but a living chemistry, working, through the laws of organized or living matter, changes infinitely more wonderful than any chemist can produce, and which he is powerless to imitate except through the same agencies.

Let it be understood, then, that digestion is not a chemical, but a vital process. Before the process was understood as well as it now is, the changes wrought were supposed to be those of fermentation, to which, indeed, the process is in some degree analogous; but we now know that fermentation occurs in conjunction with digestion only as an incidental and abnormal—though, unfortunately, a very common—process.

The Elements of Food.—A correct understanding of the philosophy of digestion and its derangements cannot be obtained without a knowledge of the nature of food and of its relation to the digestive organs in general, and to each of the digestive juices. The demand for food is created by the wearing out of the tissues by the vital activities in which they are employed. Every vital action, no matter how slight, is performed at the expense of certain portions of the living tissues. New material is constantly required to supply the want created by this waste. As there is a great diversity in the character of the several tissues of the body, it is necessary that the food should contain a variety of elements in order that each part may be properly nourished and replenished. Classified according to their relation to the digestive organs, the elements of food may be divided into the following classes:—

1. Farinaceous and saccharine.
2. Albuminous.
3. Fatty.
4. Indigestible.

These elements are sometimes found in an isolated state; but ordinarily they are combined in varying proportions. Nearly all food contains a larger or smaller proportion of each.

For description of the several classes of food, see chapter on "Food and Dietetics."

Action of the Saliva.—The saliva contains a peculiar organic principle which possesses the property of converting starch into sugar. This property of the saliva can be studied at will in the following manner: Place in the mouth a fragment of a dry cracker containing no sugar, or a small portion of well-boiled rice. Now chew it for five minutes. It will be observed that after the first few seconds it begins to have a perceptible sweet taste, which increases as the mastication is continued. A quantity of pure starch treated in the same manner will secure the same result. Evidently, sugar is formed during the chewing, as it did not exist in the starch before it was masticated. While undergoing the process of chewing, the saliva was brought in contact with the starch, and the change noted was effected. Further proof of this change is afforded by the chemist, by means of the chemical test for sugar. If a quantity of starch be submitted to the test referred to, before coming in contact with the saliva, it will be found that it contains no sugar. If the same test be applied after the starch has been mixed with saliva for a few moments, an abundance of sugar is found. This experiment we have often made in the presence of an audience, in illustrating lectures on digestion, and with effects clearly visible to all. It should be mentioned that the saliva has the same effect outside of the body as in the mouth, provided that the proper temperature is maintained.

It has been recently discovered that most of the fluids of the body possess the power of converting starch into sugar in some degree. It was formerly supposed that the action of the saliva ceased as soon as the food entered the stomach, on account of the presence of the acid of the gastric juice; but recent investigations seem to show that this is an error.

The secretion of saliva is excited by the presence of food in the mouth, or by any sweet, acid, or other sapid substance. Even the odor of agreeable foods will excite the secretion very strongly. It is also increased to a considerable extent by the act of chewing, even if the article chewed does not possess either sapid or odorous properties.

Action of the Gastric Juice.—After many years of patient study and experimentation, physiologists have at last arrived at a quite accu-

rate knowledge of the nature of the gastric juice and of its action upon the food. About the first knowledge gained was by an ingenious experimenter who inclosed different kinds of food in small perforated wooden tubes which he swallowed, and afterward vomited. He found that albuminous substances were dissolved in the stomach, so that the wooden tubes containing such foods were vomited empty, while those containing starch and fatty substances remained unchanged. Some years later, a most remarkable opportunity for the study of the gastric juice and its action was afforded by a serious accident suffered by a young Canadian. While hunting, he received in his side the full charge of a gun loaded with buck-shot and fired at the distance of a few yards. An immense rent was made in his body, which exposed not only the lungs but the inside of the stomach. Fortunately, the wounded man fell into the hands of Dr. Beaumont, an unusually intelligent physician, by whose skillful care, together with his own powerful constitution, he was restored to health after many months of suffering and imminent peril to life from the extensive sloughing of the soft parts, with injured ribs and cartilages, being finally left with a large opening through the abdominal wall into the stomach. Through this opening the food was, at first, expelled after each meal, unless retained by a bandage; but after the lapse of a few months, thoughtful nature drew a membranous curtain before it, when the injured man suffered no further inconvenience, although he could expel food through the opening at will, and often performed the experiment of drinking a quart of milk and pouring it out through the abdominal opening. The accident served to in no way interfere with his general health, and according to late accounts he is still living in Canada, though very old.

Dr. Beaumont was not slow to embrace this excellent opportunity for observation and study, and retained St. Martin for several months, and at intervals for a number of years, for the purpose of experiment and investigation. Allowing him to eat various articles, he had but to push aside the little curtain, and the long-studied mystery of stomach-digestion appeared before his eyes, solved by an accident. Dr. Beaumont soon discovered that the principal work of the gastric juice is to dissolve the albuminous elements of food. This conclusion was also proven then, as it has been hundreds of times since, by the fact that a portion of pure gastric juice, collected from the stomach, possesses the property of dissolving albuminous substances, as meat, boiled eggs, the curd of milk, gluten, etc. In repeating the experiment, physiologists

have purposely produced similar openings in the stomachs of dogs, thus enabling them to collect a quantity of gastric juice for examination at any time desired. It is even possible to separate from the gastric juice, or from the mucous membrane of the stomach of various animals, *pepsin*, the active principle of the gastric juice, and by means of it to experiment at pleasure upon its digestive properties. The pepsin which can be extracted from the stomach of a healthy dog has been estimated to possess sufficient digestive power to dissolve two hundred pounds of albumen, which would be equivalent to more than two thousand eggs.

It has also been observed that the gastric juice of calves, horses, and other herbivorous animals is much less active in digesting animal food than that of carnivorous animals.

The secretion of gastric juice is excited by the presence of food in the stomach, especially of semi-solid food, by the presence of the saliva, by sudden alternations of heat and cold, especially by the application of heat. A temperature less than that of the body causes its action to cease; a slight elevation of temperature increases its activity. Alcohol, alkalies, and tannin antagonize its action, since they precipitate the pepsin and the digested albuminous elements. Bile, which is occasionally forced upward into the stomach, has the same effect. Antiseptics of all sorts, that is, such substances as will prevent fermentation, also interfere with digestion. The metallic salts, as compounds of lead, zinc, iron, copper, etc., together with compounds of lime, magnesia, and other salts found in hard water, hinder digestion.

It has been supposed that acids of all sorts aided digestion, which theory has led to the frequent recommendation of vinegar and other acids, especially with articles difficult of digestion. This theory has been opposed by those who studied dietetics practically rather than theoretically, and now M. Charles Richet, a distinguished physician of Paris, comes forward with the assertion that he has demonstrated that acetic, tartaric, and all similar acids diminish the secretion of gastric juice while they are in no sense substitutes for it, and so hinder digestion.

Action of the Bile.—It has long been well known that the bile is an excrementitious fluid; but more recent investigations show that it also has an important office to perform in the process of digestion. The alkaline character of the bile enables it to emulsify the fatty elements of food, and by thus permanently dividing it into very small particles, renders possible its absorption. It is probable, also, that the alkaline elements of the bile to some extent saponify the fats, and thus render

them soluble in water. An additional office of this digestive fluid is to stimulate the absorption of the digested food, as well as to encourage activity of the intestinal mucous membrane. Deficiency in the quantity of the biliary secretion is a cause of constipation.

Action of the Pancreatic Juice.—This peculiar digestive fluid is unlike those which have been previously mentioned, in that its action is not confined to a single element of the food. Its office is to digest both starch and fat. It also converts cane-sugar into grape-sugar, or glucose. It thus acts upon two of the three classes of food elements.

The most recent experiments on the subject also seem to show that the pancreatic juice has power to act upon the albuminous elements of food, after they have first been acted upon by the gastric juice, so that it really completes the digestion of all the elements, though its chief function is, doubtless, the digestion of starch and fat. It has been shown very recently that removal of the spleen destroys the power of the pancreatic juice to digest albuminoid food elements.

Action of the Intestinal Juice.—This juice, of still more complicated nature than the pancreatic, digests all three of the classes of digestible foods, acting alike upon the farinaceous, the albuminous, and the fatty elements of food. This complicated function well corresponds with the compound nature of the secretion, it being the mixed product of several glands. It should be remarked, however, that the intestinal juice seems to have little power to dissolve the elements of food unless they have first been acted upon, to some extent at least, by the other digestive juices.

Review of the Action of the Digestive Juices.—Having now considered in detail the action of each of the digestive juices, we find that of the five separate fluids, three digest one each of the three classes of digestible food, while one of the remaining two digests two of the elements, and the other three, or the whole food. Considering the nutritive elements, we find that starch is digested by three separate juices, fats by three, and albuminous elements by two, which would seem to intimate that the digestion of fats and farinaceous substances is more difficult than that of albuminous elements, a fact which is abundantly confirmed by experience in the treatment of disorders of digestion.

The Digestive Process.—Before the middle of the last century very little was understood respecting the real nature of the phenomena which together make up the complete process of digestion. Since that time, the subject has been studied so carefully and patiently that physi-

ologists have now arrived at a pretty clear understanding of the matter. By far the greatest advances made in this study have been through the aid of several curious accidents by which the human stomach has been exposed to view during life, giving an opportunity for its inspection both when inactive and when in a state of activity from the presence of food. Numerous cases of this nature have been purposely produced in the dog by physiologists for further study, and hundreds of canines have suffered unwilling martyrdom at the shrine of science for the gratification of man's thirst for knowledge on this subject.

Having considered at some length the anatomy of the several digestive organs, the nature of the various digestive fluids, and the action of each upon the different elements of food, we are now prepared to consider in a connected manner the several processes of digestion. As before remarked, the digestive apparatus consists of a series of organs, of which the stomach is only one, and perhaps not the most important, since life can long be sustained without the activity of the stomach, by alimentation through the lower bowels. In the complete digestive process each one of the series of organs acts successively upon the food; and the arrangement is such that the prompt and thorough action of each organ is essential to the successful action of the succeeding ones.

In order to simplify the idea of digestion in the mind of the reader, we may remark at this point a fact which is well sustained by the most careful study of the process, that digestion really depends upon two distinct vital actions; viz., secretion and muscular action. The alimentary canal is simply a muscular tube lined with mucous membrane, along which are situated, at different intervals, secreting organs which pour into its cavity their potent juices by means of which the contents of the tube are, if possible, rendered soluble and dissolved. The chief objects of the muscular canal seem to be to move the food along and bring it in contact with the active agents of digestion. With this general view of the subject, let us now consider the several steps in the process.

In order to form an idea of normal or healthy digestion, let us observe the process in a healthy man, in whom all parts of it are purely physiological. He sits down to his breakfast about one hour after rising, having taken a little gentle exercise to arouse the activities of the system, and perhaps taken a small quantity of cold water a few minutes before to supply the demand for fluid without taking too much at the meal and to excite the gastric and intestinal secretions, as well as that of the liver, thereby insuring both an active digestion and proper activity of the bowels.

Mastication.—Our subject places in his mouth a small variety of foods containing in proper proportion the several elements of nutrition, and simply prepared, without the admixture of stimulating or irritating spices and condiments. As the food is slowly received, it is thoroughly masticated, being ground and triturated by a set of sound teeth, capable of vigorous use, and aided by the salivary secretion, until it is reduced to a pulpy mass.

Insalivation.—At the same time that this grinding process is going on, the saliva, while also aiding the mechanical division of the food, is performing its specific work upon the starch of which the food is likely to be largely composed, converting it into sugar, so that the mass of food, or alimentary bolus as it is termed, becomes sweeter in flavor the longer it is chewed.

Stomach Digestion.—After thorough mastication, each mouthful of food is in turn swallowed, being drawn down into the stomach by the muscles of the œsophagus, not simply dropping into that organ through an open tube, as many people suppose, the œsophagus being always closed, excepting only that portion which is occupied by the food in its passage to the stomach. Shortly after the food has reached that organ, its mucous membrane assumes, according to the observations of Beaumont on the stomach of Alexis St. Martin, a rosy appearance, and there may be seen oozing from its surface the gastric juice in tiny drops like perspiration on the skin. The secretion increases rapidly, and begins at once its specific action on the albuminous elements of the food, which have been made accessible by thorough mastication, which has broken up the food structures in such a manner as to expose freely all its different elements. It may occur that the gastric secretion has been excited before the food has been swallowed; in which case there is no delay whatever in the commencement of gastric digestion.

Dr. Beaumont observed, in watching patiently at the curious window-like opening in the stomach of St. Martin, that very soon after food is received into the stomach, the muscular structures of that organ begin to act, setting up a sort of churning process, turning the food over and over, squeezing, pressing, and variously manipulating it, moving it along its lower border toward the pylorus, and returning it along its upper border to the pouch-like left extremity into which it is first received from the œsophagus.

If the food contains a large quantity of fluid, this is absorbed before the process just described begins, since it is evident that too great

an amount of fluid would effectually prevent such action on the food by the muscular walls of the stomach. It is obvious, also, that a considerable amount of bulk is needed in the food, to enable the stomach to operate upon it effectually. When milk is taken, it is quickly coagulated by the gastric juice, and the whey being absorbed, the gastric juice acts upon the semi-solid masses formed. Soups, gruels, and all fluid foods, are rendered semi-solid by partial absorption of their watery constituent.

At the same time that the gastric juice is acting upon its special elements, the digestion of starch continues through the activity of the mucus of the stomach, the saliva being neutralized by the gastric juice when the food reaches the stomach. Absorption of the portions of the food which are rendered liquid by digestion is all the time taking place, so that the semi-solid character of the mass is in a measure preserved.

After this process has continued for a time, which is longer or shorter according to the nature of the food or the manner of its preparation, portions of food begin to pass out of the stomach. As the mass is moved along the lower border of the stomach toward the pylorus, the orifice is opened a little, instead of being tightly closed as before, and small portions of food which have been properly acted upon by the stomach and the gastric juice, are allowed to pass through. If approached by portions of undigested food, the pylorus contracts strongly and allows none to pass. By this means the food is kept in the stomach until gastric digestion has been well completed. A curious fact, however, rather difficult of explanation, is that the pylorus seems to possess a peculiar faculty for discovering whether substances brought in contact with it ought to be digested in the stomach or not. Unbroken seeds, as cherry stones, apple and grape seeds, etc., together with pieces of glass, stone, or other insoluble substances, are allowed to pass without opposition. After a time, the acidity of the food becomes so great from the increase of gastric juice, that the stomach is excited to strong contraction, and the whole mass is crowded through the pylorus into the small intestine, where the work is completed. The length of time intervening between the ingestion of food and the emptying of the stomach varies from an hour or an hour and a half, when the article eaten is boiled rice or a mellow apple, to between five and six hours after eating fat pork or similar food. The figurative expression used by laborers who claim that pork is an excellent article of food because it "sticks by the rib," rendered literally, means

that it is so difficult of digestion that the stomach has hard work to get rid of it after it has been received.

Intestinal Digestion.—While stomach digestion has been going on, the gastric juice acting upon the albuminous elements of the food, and the digestion of the starch slowly progressing, the fatty elements of the food have undergone no changes except such as have resulted from the elevated temperature. Being to some extent freed from its association with the other elements, the fat floats upon the surface of the contents of the stomach, when fluid, but undergoes no further change until it comes in contact with the bile and pancreatic juice in the duodenum, when those fluids act upon it in the manner already described. The pancreatic juice also acts vigorously upon the portions of starch remaining undigested, and such portions of cane sugar as may have escaped digestion or absorption in the stomach.

We now have all the elements of food acted upon by the saliva, gastric juice, bile, and pancreatic juice, but, lest any portion should escape undigested, nature provides the intestinal juice, which continues its action upon all the elements of food alike during the whole of its passage through the small intestine, and perhaps to some extent in the large intestine also.

During the process of intestinal digestion the food is slowly moved along through the twenty-five feet of small and large intestines, gradually becoming more and more solid by the absorption of the portions rendered fluid by the digestive juices, and also gradually being more and more completely deprived of its nutrient elements, until at last there is left in the lower part of the large intestine nothing but the innutritious residue of the food, mixed with the excrementitious products of the intestinal mucous membrane, constituting alvine matter, or feces, which are destined in due time to be discharged from the body, such a discharge occurring normally as often as once in twenty-four hours, in most persons, and usually in the morning before or just after taking breakfast.

Absorption.—The process of absorption begins almost as soon as food is taken into the mouth, and continues so long as any soluble nutriment can be extracted from the alimentary mass. The work of absorption is performed by two sets of absorbent vessels, minute veins, and lymphatics, here called lacteals. The venous absorbents take up whatever is held in solution, in the fluid taken into the stomach, and the principal portion of the digested farinaceous, saccharine, and albu-

minous elements of food. The lacteals (See Fig. 129) absorb the emulsified fats, and some portion of the other elements. The products absorbed by the venous absorbents find their way into the general circulation through the hepatic vein, after passing through the liver, which is apparently a wise arrangement of nature, to provide for a sort of filtration before the more delicate tissues of the body are exposed to the action of whatever deleterious elements the food may happen to contain. It is claimed by physiologists that the liver has also an important function to perform in completing the work of digestion, especially that of starchy substances. The food mingled with venous blood is conveyed to the liver by the portal vein. Those products which are absorbed by the lacteals, reach the general circulation through the thoracic duct, a long, slender lymph vessel which empties into the large vein from the arm on the left side.

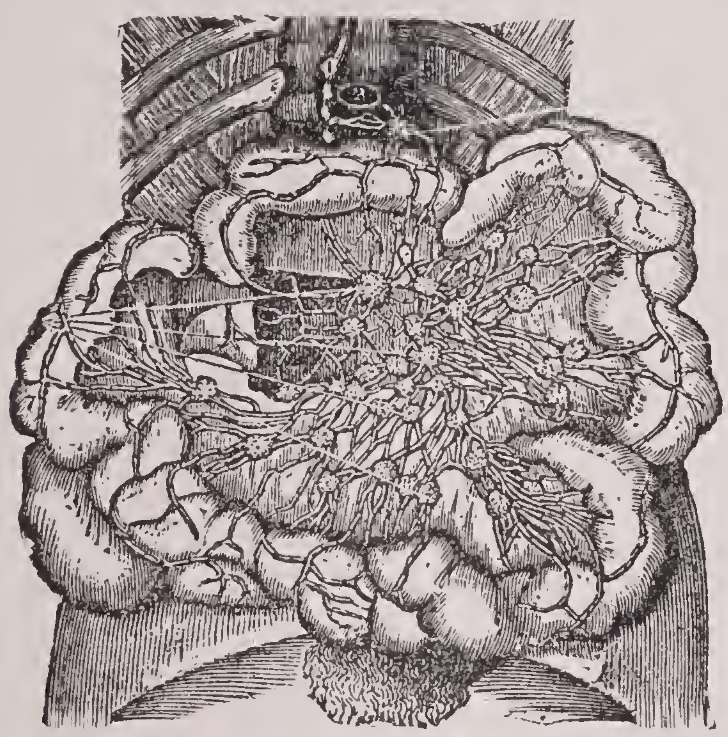


Fig. 129. A portion of the Intestinal Canal showing Mesenteric Glands and Lacteals.

Oxygenation.—From the right heart the mixed products of digestion are sent to the lungs, where, by coming in contact with the oxygen of the air, the final change is effected, whereby heterogeneous organized matter is converted into human blood, with properties and qualities to nourish and repair each of the great variety of delicate tissues found in the body. After the blood has passed through the lungs, neither sugar nor fat, which may abound in the blood before its oxygenation, are found.

We have now traced through its various subdivisions the entire process of digestion, and found, until we came to the process of absorption, that, as at first remarked, the process chiefly depends on two vital actions; viz., muscular action, and secretion. Muscular action masticates the food—by the aid of the passive accessory organs, the teeth—and mingles with it the saliva. Muscular contraction draws the alimentary bolus from the mouth down into the stomach. Here,

by the action of the muscles, it is churned up with the gastric juice, and finally squeezed through the pylorus into the small intestine, where, by the aid of muscles, it is mixed with the bile and the pancreatic and intestinal juices, and is moved along, constantly coming in contact with fresh secreting and absorbing surfaces, until its digestion is complete. Even absorption is greatly aided by this muscular action, as the circulation in the absorbing parts is thereby quickened, so that larger quantities of fluid are taken up.

Nervous Relations.—Before leaving the physiology of digestion it should be noted that both the secretion of the digestive fluids and the muscular action of the stomach and intestines are under the control of nerves. The digestive organs are all intimately connected with the general nervous system, so that any change in one is readily noted in the other. A demand for nutriment in the general system is referred to the stomach as hunger, just as the demand for liquor is referred to the throat as thirst. Undigested food, or any other obnoxious substances in the stomach, may excite a nausea which will relax and prostrate the whole system. In certain states of the system, and especially in young children, disorder of digestion may even produce convulsions. On the other hand, we see that agents which affect the general nervous system often influence the digestive organs indirectly with almost the promptness of agents addressed directly to them. The sight or smell of savory viands will "make the mouth water" by exciting the salivary secretion. Seeing or smelling disgusting objects will not infrequently cause prompt emesis, when there is nothing whatever in the stomach to occasion vomiting. In a case which came under our observation a few years ago, a gentleman was deprived of several meals by having had the misfortune to meet a very loathsome object. Whenever he attempted to eat, an image of the repulsive object came before his mind, and the immediate nauseating effects were so great as to make it impossible for him to keep anything in his stomach. On more than one occasion a patient has been made to vomit by being told that he had taken an emetic, when the dose he had swallowed was inert.

Vomiting.—This is evidently a result of reflex nervous action in most cases. The exact mechanism of the act we do not need to explain, except to say that the expulsive effort is made chiefly by the abdominal muscles and the diaphragm, the stomach taking little active part in the process; being powerfully compressed against the rigid

diaphragm, by the vigorous contraction of the abdominal muscles, its contents are forcibly expelled upward through the œsophagus, contraction of the pylorus preventing exit from the stomach in a downward direction.

Retching is an effort of the same character as vomiting, only less in degree. Gulping is a peculiar action by which air is drawn down into the stomach. It frequently precedes vomiting, having the effect to relax the sphincter muscle at the lower end of the œsophagus. Other abnormal actions connected with the stomach and bowels will be explained in connection with the diseases of these organs.

HYGIENE OF DIGESTION.

Probably no part of the vital economy is subjected to so much abuse as the digestive organs. The majority of people eat and drink what their fancy or tastes call for, not once taking into account any possible injury which may result to the stomach from what is put into it. The stomach is treated like a garbage box, and then is expected to do its duty, or rather to dispose of the indigestible messes imposed upon it promptly and uncomplainingly. If it lags a little in weariness from overwork, instead of being allowed to rest like any other organ of the body when tired, it is whipped up and goaded on by stimulants in the shape of spices, mustard, pepper, and other condiments, and often even with wine, beer, ale, brandy, and other artificial means of getting out of an organ more work than it is able to do.

The importance of this subject demands serious attention. Its neglect has made the American people a nation of dyspeptics. We may therefore be justified in devoting considerable space to this topic, and going quite fully into the details of it, so that some practical benefit may be derived from its consideration.

From our study of the anatomy and physiology of digestion we have acquired a pretty good knowledge of the principles of the subject. Now let us apply these principles, and by so doing we shall be able to discover that many of the most common customs relating to eating and drinking are in direct opposition to the laws of healthy digestion. And first, as one of the most common of all dietetic errors we will mention—

Hasty Eating.—That Americans are everywhere noted for the precipitate manner in which they bolt their meals, tumbling into their

stomachs indiscriminately material that is digestible and indigestible, and spending only enough time to reduce the food to a sufficient degree of fineness to allow it to be swallowed without choking,—often hardly enough for safety in that regard,—is too well known to require special confirmation. The average American eats as he works, recreates, and does everything else, in fact, on the high-pressure system. He treats his mouth like a corn-hopper, and his stomach like a garbage box.

The evils resulting from hasty eating may be enumerated as follows :—

1. From deficient mastication, the food is not properly divided, so that the digestive juices cannot gain access to its various elements.

2. By being retained in the mouth too short a time, an insufficient amount of saliva is mingled with it, so that salivary digestion cannot be properly performed. As the saliva is also a stimulus to the secretion of gastric juice, stomach digestion must necessarily be imperfect.

3. Again, the food entering the stomach in a coarse, unmasticated state, may act as a mechanical irritant to the delicate lining of the stomach, and thus occasion congestion and gastric catarrh, one of the most common disorders of the stomach, and one which is often very obstinate in its nature.

Drinking at Meals.—In addition to the evils which it occasions directly, hasty eating induces an individual to drink largely of hot or cold liquids to wash the food into the stomach. Thus, two evils are associated. Liquid of any kind, in large quantity, is prejudicial to digestion because it delays the action of the gastric juice, weakens its digestive qualities, and overtaxes the absorbents. In case the fluid is hot, if in considerable quantity, it relaxes and weakens the stomach. If it is cold, it checks digestion by cooling the contents of the stomach down to a degree at which digestion cannot proceed. Few people are aware how serious a disturbance even a small quantity of cold water, iced cream, or other cold substance, will create when taken into a stomach where food is undergoing digestion. This process cannot be carried on at a temperature less than that of the body, or about 100°. Dr. Beaumont observed that when Alexis St. Martin drank a glassful of water at the usual temperature of freshly drawn well-water, the temperature of the food undergoing digestion fell immediately to 70°, and did not regain the proper temperature until after the lapse of more than half an hour.

Of course the eating of very cold food must have a similar effect, making digestion very tardy and slow. If any drink at all is taken, it

should be a few minutes before eating, time being allowed for absorption before digestion begins, or an hour or two afterward. If the meal is mostly composed of dry foods, a few sips of warm or moderately hot water will be beneficial rather than otherwise, taken at the beginning of the meal or at its close. The habit of drinking during the meal should be discontinued wholly, and especially by those whose digestive powers are weak. If the diet is of proper quality, and the food is well masticated, there will be little inclination to eat too much. When the food is rendered fiery and irritating with spices and stimulating condiments, it is no wonder that there is an imperious demand for water or liquid of some kind to allay the irritation.

Eating too Frequently.—One of the most pernicious customs of modern society is that of frequent meals. This custom is seen in its extreme development in England more clearly than in this country, five meals a day, including lunches, being there thought none too many. The idea seems to prevail that the stomach must never be allowed to become empty under any circumstances. In this country, three meals a day is the general custom, though more are often taken. Healthy digestion requires at least five hours for its completion, and one hour for rest before another meal is taken. This makes six hours necessary for the disposal of each meal. If food is taken at shorter intervals than this, when ordinary food is eaten, the stomach must suffer disturbance sooner or later, since it will be allowed no time for rest.

Again, if a meal is taken before the preceding meal has been digested and has left the stomach, the portion remaining, from its long exposure to the influence of warmth and moisture which especially favor fermentation, is likely to undergo that change in spite of the preserving influence of the gastric juice, and thus the whole mass of food will be rendered less fit for the nutrition of the body, and the stomach will be liable to suffer injury from the acids developed.

Eating between Meals.—This is a gross breach of the requirements of good digestion. The habit many have of eating fruit, confectionery, nuts, sweetmeats, etc., between meals, is a certain cause of dyspepsia. No stomach can endure such usage. Those who indulge in this manner usually complain of little appetite, and wonder why they have no relish for their food, strangely overlooking the real cause, and utterly disregarding one of the plainest laws of nature.

This evil practice is often begun in early childhood. Indeed, it is too often cultivated by mothers and the would-be friends of little

ones, who seek to gratify them by presents of confectionery and other tid-bits of various sorts. Under such a regimen, it is not singular that so many thousands of children annually fall victims to stomach and intestinal diseases of various forms. In great numbers of cases, early indiscretions of this sort are the real causes of fully developed dyspepsia in later years.

Irregularity of Meals.—Another cause of this disease, which is closely related to the ones just mentioned, is irregularity respecting the time of meals. The human system seems to form habits, and to be in a great degree dependent upon the performance of its functions in accordance with the habits formed. In respect to digestion this is especially observable. If a meal is taken at a regular hour, the stomach becomes accustomed to receiving food at that hour, and is prepared for it. If meals are taken irregularly, the stomach is taken by surprise, so to speak, and is never in that state of readiness in which it should be for the prompt and perfect performance of its work. The habit which many professional and business men have of allowing their business to intrude upon their meal hours, quite frequently either wholly depriving them of a meal or obliging them to take it an hour or two later than the usual time, invariably undermines the best digestion, in time. Every individual ought to consider the hour for meals a sacred one, not to be intruded upon under any ordinary circumstances. Eating is a matter of too momentous importance to be interrupted or delayed by ordinary matters of business or convenience. The habit of regularity in eating should be cultivated early in life. Children should be taught to be regular at their meals and take nothing between meals. This rule applies to infants as well as to older children. The practice of feeding the little one every time it cries is a most serious injury to its weak digestive organs. An infant's stomach, though it needs food at more frequent intervals,—two to four hours according to its age,—requires the same regularity which is essential to the maintenance of healthy digestion in older persons. The irregularity usually practiced is undoubtedly one of the greatest causes of the fearful mortality of infants from disorders of the digestive organs, as appears in our mortuary reports.

The subject of infant feeding is a very important one, and on this account we have devoted considerable space to it in the chapter on "Food and Dietetics," which see.

The Proper Number of Meals.—How many meals should be taken by a person in health? The answer to this question depends somewhat upon the habits of the individual, his occupation, number of hours of labor, etc. There is good reason to believe that for a large share of those who now take three to five meals a day, two would be much better. According to Hippocrates, the ancient Greeks ate but two meals a day. This was the prevailing custom in olden times. Indeed, the modern frequency of meals is the outgrowth of a gradual losing sight of the true function of food and of eating, and making the gratification of the palate the chief object, instead of the nourishment of the body. It is distinctly a modern custom. That the system can be well nourished upon two meals a day is beyond controversy, seeing that not only did our vigorous forefathers require but two meals a day, but hundreds of persons in modern times have adopted the same custom without injury, and with most decided benefit. Students, teachers, clergymen, lawyers, and other literary and professional men, will be especially benefited by this plan. We have employed it for about fifteen years, and with great benefit. The special advantages gained by it are, 1. The stomach is allowed a proper interval for rest; 2. Sleep is much more recuperative when the stomach is allowed to rest with the balance of the body; 3. Digestion cannot be well performed during sleep.

If six hours are allotted to each meal, and the proper length of time is allowed to elapse before going to sleep after the last meal, it will be found impossible to make any arrangement by which opportunity can be secured for the necessary eight hours' sleep at night. Not more than two meals can be taken when a person complies with all the laws of health.

If more than two meals are required by any one, it is by those who are engaged for twelve or more hours per day in severe physical labor. Such persons are better prepared to digest a third meal than those whose occupation is mental or sedentary, and they may at least take it with less detriment, though we are still doubtful whether a third meal is needed, even for such.

Eating when Tired.—This is one of the most certain causes of derangement of digestion, and one to which a very large number of cases of dyspepsia may be traced. The third meal of the day is almost always taken when the system is exhausted with the day's labor. The whole body is tired, the stomach as well as the rest. The

idea that by the taking of food the stomach or any other part of the system will be strengthened, is a mistake. When the stomach "feels faint and tired" at night, as many people complain, what it wants is not food, but rest. An eminent writer on indigestion says very truthfully, "A tired stomach is a weak stomach." When the stomach feels "weak and faint," rest is what is demanded, and is the only thing that will do it good; yet many people insist on putting more food into it, thus compelling it to work when it ought to be allowed to remain inactive until rested. The arm wearies by constant exercise, and so does the stomach, which is largely composed of muscles as well as the arm. Both secretion and muscular activity must be much lessened in a tired stomach, and the habitual disregard of this rule must be disastrous to the best digestion.

Violent exercise at any time just before or just after eating is inimical to good digestion, for the reason already assigned when the exercise is taken just before the meal, and because the vital energies are diverted to other parts—thus robbing the stomach of its necessary share—when the exercise is taken immediately after eating. An English physiologist performed an experiment which well illustrates the truth of this position. Having fed a dog his usual allowance of meat one morning, he took him out upon a fox hunt, and kept him racing over the country until night, when, having killed the animal, he examined his stomach at once and found the meat in the same condition in which it entered his stomach, no digestion having taken place. In another dog, fed with the same kind of food, but left quiet at home, digestion was found to be complete.

The hurry and press of business among Americans is allowed to override every consideration of health. It seems never to enter the thoughts of the average business man that any time is required for digestion. Rushing to his dinner from the plow, the workshop, or the counting-room, he swallows his food with all possible dispatch, and rushes back to his work again, begrudging every moment spent in meeting the requirements of nature. Many years ago, it was a custom in Edinburgh to suspend all business in the middle of the day for two hours, so as to allow ample time for meals. A similar custom once prevailed in Switzerland, we have been informed; but we presume that such a sensible custom is now considered too old-fashioned to be tolerated.

It should be remarked that severe mental labor immediately before or after, and especially during meals, is even more injurious than

physical employment. The habit many business men have of anxiously scanning the newspapers during their meals and when going to and from their places of business, is a bad one. A full hour, at least, should be taken for the midday meal; and if an hour's rest can be secured before eating, improved digestion would well repay the time spent in re-inforcing the vital energies. For persons of weak digestion, the rest before eating is in most cases indispensable.

The famous *L'Homme serpent* (man snake), of Paris, who astonished the world by his agility and wonderful contortions, ate but two meals a day of vegetable food, and invariably abstained from food for twelve hours before performing, a plan which was undoubtedly mutually advantageous to his muscles and his stomach, as his exercises required great muscular effort.

Sleeping after Meals.—While rest from accustomed exercise after eating is important, it should be noted that sleep at this time is equally as bad as vigorous exercise of either mind or body. Good digestion cannot take place during sleep. While it is true that digestion is an involuntary act, it should be recollected that it is dependent upon the activity of the nervous system for its proper performance. The same nerve which secures activity of the respiratory organs, the *pneumogastric*, controls the muscular activity of the stomach and intestines. During sleep, from the lessening of nervous activity both the respiration and the circulation are greatly lessened in vigor. It is but reasonable to suppose that the activity of the digestive organs is decreased at the same time, being controlled by the same nerves. Actual experiment shows this to be true. Most people who lie down and sleep an hour or two soon after taking food, awake feeling anything but refreshed. The suspension of the process to a considerable degree during sleep causes imperfect digestion with its numerous unpleasant symptoms. In the case of old people it may sometimes be beneficial, or at least not harmful, to secure a few minutes' sleep after eating, before digestion is well begun, but it must not be long continued.

In order to secure the best conditions for digestion after eating, an individual should take gentle exercise of some kind, as walking, carriage or horseback riding While violent exertion seriously interrupts the digestive process, a moderate degree of physical exercise facilitates the process by increasing the muscular activity of the digestive organs and thus encouraging both secretion and absorption.

Late Suppers.—Eating late at night, when the muscular and nervous systems are exhausted by the labor of the day, and then retiring soon to rest, is one of the most active dyspepsia-producing habits to which modern society is addicted. As before explained, "a tired stomach is a weak stomach;" and in addition, we may add, a sleepy stomach is a sluggish one. Secretion must of necessity be deficient in both quantity and quality, owing to the exhausted condition of the system; and with the further obstacle afforded to prompt digestion by the slowing of the vital operations during sleep, it is almost impossible that there should be other than disturbed digestion and disturbed sleep in consequence. It is under these circumstances that people often suffer with obstinate insomnia, bad dreams, nightmare, and similar troubles, from which they arise in the morning unrefreshed, and unrecuperated by Nature's sweet restorer, the work of assimilation, by which repair takes place, having been prevented by the disturbed condition of the nerves.

No food should be taken within three or four hours of retiring. This will allow the stomach time to get the work of digestion forward sufficiently to enable it to be carried on to completion without disturbance of the rest of the economy. The last meal of the day, if three meals are taken, should be a very light one, preferably consisting of ripe fruit and simple preparations of the grains. The custom which prevails in many of the larger cities of making dinner the last meal of the day, eating of articles the most hearty and difficult of digestion as late as six or even eight o'clock, is one that ought to be discountenanced by physicians. It is only to be tolerated at all by those who convert night into day by late hours of work or recreation, not retiring until near midnight. But in such cases, a double reform is needed, and so there can be no apology offered for this reprehensible practice on any physiological grounds.

Too Many Varieties of Food.—Many dyspepsias arise from the eating of too many kinds of food at the same meal, another growing custom in modern times which deserves to be distinctly condemned. At great dinners in honor of distinguished personages, when friends are to be entertained, and in the majority of well-to-do families as a general custom, the eaters are tempted to gluttony by having presented to their palates a great variety of complicated dishes, almost any one of which would be too much for the digestive organs of most inferior animals. On the occasion of the giving of a great dinner to some notable, we have known instances in which more than a hundred dishes were served in

successive courses. Such gormandizing soon breaks down the most vigorous digestive organs, since it adds to the labor of digesting food which is improperly cooked, a larger variety than the digestive juices are capable of bringing into a fit state for absorption. Careful experiments have shown very clearly that different classes of food require a particular quality of digestive juices for their digestion. For instance, a gastric juice that will digest animal food the best, is inferior for the digestion of vegetable food, and *vice versa.* The obvious conclusion to be drawn from this fact is that the simpler the dietary, the more perfectly will the digestive process be performed. For persons whose digestive powers are naturally weak this is a matter of special importance. Such will find it well to avoid eating meat and vegetables together. Meat and grains may be taken together, but not meat and vegetables, by persons of weak digestion, the latter being much more difficult of digestion than either of the others. If the bill of fare taken at a single meal were confined to three or four articles of food, there would be fewer dyspeptics scanning the newspapers for some patent nostrum to "aid digestion."

Hot and Cold Bathing after Meals.—Especial mention should be made of the injury to the digestive organs quite certain to result from taking either a hot or a cold bath soon after eating, as few people are aware of the danger of laying the foundation for years of discomfort in this way. If the bath be a hot one, the stomach will be deprived of the blood necessary to support the rapid secretion of gastric juice for the digestion of the food, by the sudden relaxation of the capillaries and arterioles of the skin, drawing the blood to the surface of the body. A cold bath, on the other hand, or any sudden exposure to cold, may, by causing contraction of the blood-vessels of the surface of the body, cause sudden congestion of the stomach, which is equally fatal to good digestion. Very nearly the same danger exists from the taking of baths just before a meal.

The practice very common among boys and young men, of going into the water in the summer time regardless of the condition of the stomach or of other states of the body, is a bad one. With many it is a very usual practice two or three times a week if not more often, to go at once into the water after the evening meal, not allowing even time for the work of digestion to become established. No bath involving any considerable portion of the body should be taken within two hours of a meal.

Errors in Quantity of Food.—If errors in the manner of taking food are active causes of indigestion, mistakes in quantity are still more potent in this direction. It should be noted, however, that errors of this class are very closely connected with errors in the manner of eating, and in the quality of food taken. It is generally true with physical as well as moral transgression, that one bad habit implies another; and especially is this the case in reference to dietetic errors. A person who eats too fast is likely to eat more than is necessary; and the same is true if too large a variety of food is partaken of, or food rendered exciting and stimulating by seasoning with irritating condiments.

Overeating.—Intemperance in eating is, in our opinion, responsible for a greater amount of evil in the world than intemperance in drinking. We do not fear to make this statement, since we believe it can be clearly shown that intemperate eating is, in the first place, one of the most potent causes of intemperance in drinking, and, secondly, that it is one of the greatest obstacles in the way of the reformation of those who have become victims of alcoholic intemperance.

If we may believe the statements of historians, gluttony is by no means a modern vice. Indeed, there is quite good ground for believing that overeating, while a very general fault, is rarely if ever carried to the enormous excess to which some of the luxurious Roman emperors indulged, as for instance, the Emperor Maximus, who consumed forty pounds of flesh in a day; or Caligula, whose custom was to eat until compelled to desist from having distended his stomach to its utmost capacity, and then taking an emetic to enable him to repeat his gormandizing.

The evil consequences of excess in eating are at first simply imperfect digestion, the overtaxed organs being unable to accomplish the complete digestion of the alimentary mass. In consequence of the delay which occurs, changes take place by which acids are developed which irritate the mucous membrane, together with gases by which the stomach is distended and its muscular walls weakened and partially paralyzed. In course of time, inflammation of the gastric membrane is developed, and permanent dilatation of the stomach occurs.

At first, an individual who overeats will be likely to accumulate flesh quite rapidly; but very soon the digestion becomes so much disturbed that no gain takes place, and, indeed, the patient not infre-

quently becomes considerably emaciated even while daily taking large quantities of food. When the opposite is the case, the blood is filled with crude, imperfectly elaborated material, which, when assimilated, produces a poor quality of tissue.

Eating too Little.—A far less common fault than that last mentioned, is eating too little. The instances that occur are usually in the cases of those who have attempted to subject themselves to a rigid dietetic regimen for the prevention or cure of disease, and who, from having only a partial view of the subject, entertain extreme notions. By the weakening of the system which necessarily occurs when an insufficient amount of nutriment is received, the stomach also becomes weak and debilitated, its secretions and muscular efforts being greatly impaired in both quantity and quality. This is well seen in persons who have been long deprived of food. When allowed to eat, they are unable to digest but the smallest quantity of food; and though the system is famishing for nourishment, an amount of food equal to that taken at an ordinary meal would be almost as fatal as a dose of strychnia.

How Much Should a Person Eat?—Hundreds of times have we been asked this question; but we have never been able to give any other answer than might be suggested by the common sense of the questioner, without medical assistance. The only reply that can be made to this question is, just so much as the system needs and the digestive organs can digest. In general, an individual may take as much food as he can digest; but often there are conditions in which he cannot digest as much as he really needs. For instance, when an individual is called upon to exert all his energies of brain and muscle, to strain every nerve to its utmost to compass a certain object of great importance, to cope with an emergency, he may be for the time being quite unable to digest sufficient food to make good the waste that must necessarily occur. He will lose flesh and strength under such circumstances; and often a failure of the appetite at such a crisis indicates the inability of the stomach to digest, from the deficient secretion of gastric juice. It is on this account that persons who are for a time called upon to make great exertions often break down their digestion. Thinking that they need abundance of nutriment, which is true, they eat as heartily as when required to perform only their ordinary work, not considering their diminished power to digest

and appropriate food, and in a short time find their digestive organs unable to digest well even a small amount of food.

We are satisfied that it is in this way that many lawyers, physicians, and other professional men, break down. If, when called upon to do a large amount of extra work, the individual would lessen the quantity of food eaten, instead of increasing it, he would conserve his vital forces much more than by pursuing the opposite course. When required by the press of business to do extra work, often working for several days in succession with very little sleep, we have been in the habit for several years of limiting the amount of food taken to not more than half the usual allowance, and sometimes to even a less quantity. The result has invariably been all that could be desired; since, although we have often lost several pounds of flesh during an ordeal of this kind, when it is past, and we return to our usual routine of work, we bring back from the effort our digestion intact, and are able to digest the amount of food necessary for recuperation, so that a few days suffice to restore us to our usual weight, and without loss of either strength or time.

It is evident that the diet of each individual must be regulated in quantity according to his occupation. It must also be adapted to his age. A man engaged in severe physical labor, while he really *requires* less food, may be able to *dispose of* more food than one who labors with equal intensity in some mental pursuit. The body is wasted much more rapidly by vigorous brain labor than by physical exercise. Indeed, it is asserted by our best authorities in physiology, that three hours of severe brain labor are equal in exhausting effects upon the system to ten hours of physical labor or muscular effort. It is evident, then, that a man who works his brain constantly for ten or twelve hours a day really needs more food to sustain his strength than a man who employs his muscles for the same length of time. But, as before remarked, the muscle laborer may be able to *dispose of* more food than the brain laborer, though he *needs* less, since his vital forces are not so completely exhausted by his work. In other words, the occupation of the muscle worker being less exhaustive than that of the brain worker, he can overeat with greater impunity than can the latter. Each should eat but the quantity actually required, if he would enjoy the maximum of health and vigor; but for the man whose vital energies are daily exhausted by mental effort, any excess in eating is certain to be most disastrous. We have examples of great

literary men who have been great eaters; but it is a noticeable fact that these persons, in many instances, while celebrated for their productions, often worked very leisurely, their fame being really more justly attributable to brilliant genius than to great application. In several cases, too, as in that of Charles Dickens, who is said to have been a large eater, the hours spent in brain labor were chosen from the best of the day, many hours being spent in physical exercise, by which means the integrity of the digestive organs was maintained much better than would otherwise have been the case. In not a few instances, too, those great literary men who were noted eaters died early, their physical stamina being exhausted by the double draft made upon it. Newton, when engaged in the most severe portion of his wonderful labors in demonstrating the law of gravitation by computations respecting the orbit of the moon, confined himself to a spare diet of bread and water.

The amount of food required by an individual, as already intimated, varies at different periods of life, according to the degree of vital activity. In infancy and childhood, when the vital activities are at their highest degree of intensity, when growth and development are to be maintained in addition to supporting the wastes of the system, the demand for food is greater in proportion to the size of the individual than at any subsequent time. In adult life, when waste and repair are about equally balanced, a sufficient amount is needed to make good the daily loss from the various mental, physical, and other vital activities, which can only be supported at the expense of tissue. Any larger quantity than this is excess.

In old age, when the assimilative powers are weakened by declining years, the amount of food which can be assimilated by the individual is even somewhat less than what is really needed; hence, as age advances, the quantity of food should be gradually diminished. Very many old people break down much sooner than they would otherwise do were they more careful in this regard. When they lay aside their vigorous, active life, they should also curtail the quantity of their food. By this act of temperance, they might preserve intact to a much later period the integrity of their digestive organs, and so add years to their lives.

In not a few instances, the foundation of dyspepsia is laid by some mechanical injury, as a sprained ankle, a broken limb, or a severe bruise or cut, which requires rest from active exercise for a few

weeks. Not considering the fact that much less food is demanded when an individual is not engaged in active labor of any sort than at other times, the individual continues to eat heartily, and soon finds, that, from sheer exhaustion, the digestive organs refuse to do their work. On this account it should be made a uniform custom to eat lightly on the weekly rest-day. The hearty Sunday dinners in which many people indulge, making the day an occasion of feasting rather than a rest-day, cannot be too much condemned. The custom is without doubt responsible for many other forms of Sabbath-breaking, as no individual can have a clear perception of right and a quick sense of wrong when laboring under the incubus of an overloaded stomach. For the hearty meal usually taken, it would be well to substitute a light one consisting mostly of fruits and grains. This plan, if pursued, would do away with much of the drowsiness in church, of which many people and not a few pastors have abundant reason to complain. The intellect would be much clearer, and so better able to appreciate the privileges and comforts of religion. The sooner people recognize the fact that stomachs have much to do with religion, and that true religion includes the government of the appetite, and frowns upon abuse of the stomach as well as upon abuse of a fellow-man, the better it will be for both their stomachs and their religion. We are not sure but that many gloomy theological dogmas were born of bad stomachs and inactive livers; and we are very certain that one of the best preliminary steps toward converting a sinner is to reform his stomach.

Each individual must be to a considerable extent his own guide respecting the exact amount of food to be taken at a single meal. If the appetite has been so long abused that it is no longer a safe guide, then reason must rule. The individual should, at the beginning of the meal, determine just how much he will eat, and when the specified quantity is taken, he must resolutely stop eating, leaving the table if necessary, to escape temptation. The practice of serving fruit, puddings, nuts, confectionery, and tidbits of various kinds, as "dessert," is a pernicious one. In the first place, it is an inducement to overeat, since it is quite probable that enough has been eaten before the dessert is served. If the articles offered are wholesome, they should be served and eaten with the meal, as a part of it, and not at its close, in addition to the meal. Furthermore, it is generally the case that most of the articles served at dessert are wholly unfit to

be eaten at any time, and so should be discarded. Dessert is really an ingenious device to induce people to make dyspeptics of themselves by eating more than they need.

A man who desires to be at peace with his stomach should learn to "stop when he has enough," no matter how strongly he may be tempted to do otherwise. There is much more truth than poetry in the old Scandinavian proverb, "Oxen know when to go home from grazing; but a fool never knows his stomach's measure." But experience, a dear school, ought after a time to teach the most unobserving person the amount of food his stomach will bear without discomfort, and without injury. If a person in fair health finds that after eating of wholesome food, he is troubled with fullness of the stomach, dullness over the eyes, "sour-stomach," eructations, or flatulence, he may be very sure that he is eating too much, and he should continue to diminish the amount taken at each meal until the symptoms mentioned disappear.

By reference to the table given on page 370, it will be possible to ascertain with ease the amount of nutriment consumed in any given quantity of different varieties of food. It is worthy of remark that the grains, as shown in the table above mentioned, are by far the most nutritious of all the various classes of food. It will be observed, for instance, that oatmeal, Indian meal, and peas contain three times as much real nutriment as lean beef. When economy must be considered in the selection of food, this is a very important consideration. This becomes doubly evident when we consider that it takes eleven pounds of vegetable food, including Indian meal, dry hay, etc., to make one of beef. Thus it appears that as nutriment one pound of oatmeal at first-hand is as valuable as thirty or more pounds taken at second-hand, through the medium of beefsteak.

Deficient Food Elements.—While the food may be abundant in gross quantity, it may be deficient in some one or more of the various important elements which go to make up the food. If the food is deficient in farinaceous and fatty elements, the individual will soon show signs of suffering in consequence. A lack of the nitrogenous elements will occasion still more marked effects, the stomach losing its tone and vigor, giving rise to acidity, flatulency, and various associated disturbances. The deficiency of the coarser, innutritious elements of the food, is also very soon felt by diminished activity of the stomach and bowels, both in secretion and in muscular action. Hence the great importance of choosing carefully and judiciously the articles of food to be taken, es-

pecially when a regular dietary is to be followed. Such a selection should be made as will supply to the system all the elements of nutrition in proper quantity. To employ a dietary in which any one of the nutritive elements is deficient, although the quantity of the food may be all that the digestive organs can digest, is as really starvation, and will as certainly occasion the same results ultimately, as total deprivation of food. To attempt to live on white bread and butter and strong tea or coffee, is as certain to impoverish the blood as refraining from eating altogether, the only difference being in the length of time required to bring about the result. Thousands of pale-faced, anæmic, thin-blooded, nerveless, dyspeptic women owe all their troubles to an impoverished diet. Tea drunkenness, in which an individual attempts to subsist on the Chinese herb almost wholly, is a not uncommon thing; and in consequence of its pernicious influence, the sagacious physician not infrequently finds as well marked cases of scurvy among ladies of the higher classes of society as among the poorly fed sailors of the whaling vessel after a long voyage with prolonged confinement to a monotonous saline diet. Young ladies who attempt to exist with little other food than tea, pastry, and confectionery, need not wonder that they grow to be lank and sallow and hollow-eyed dyspeptics. Under such a regimen, the most hardy quadruped would succumb.

Many parents weaken the digestive organs of their little ones for life by feeding them when very young upon such insufficient diet as corn-starch or arrowroot gruel, and similar preparations, and when they become older, upon fine-flour bread. Repeated experiment has shown that a dog will die of starvation in a month when fed upon white or fine-flour bread alone. Fed upon bread made of the whole grain, or graham bread, dogs as well as other animals suffer no deterioration in weight or in strength. The difference between fine flour and graham flour is largely in the proportion of gluten which they contain. Fine flour is made from the innermost portion of the grain, which is almost pure starch, thus excluding the brain, nerve, and muscle nourishing elements which are found chiefly in the portions of the kernel that lie next the outer husk. Whole-wheat flour also contains portions of innutritious matter which, under most conditions, are advantageous, encouraging both secretion and muscular activity of the bowels, and thus preventing constipation, which is often a forerunner of more serious disease of the digestive organs. There are cases in which the coarser portions of the bran are injurious by causing irritation; but these cases do not often occur.

While it is necessary to have all of the elements of the food in proper proportion, it is of first importance that the nitrogenous elements should be sufficient in quantity, even if it should be necessary to take an excess of the farinaceous elements to secure the proper amount, since it is of these elements that the vital portions of the body are formed. By reference to the table given on page 880 it may be ascertained what quantity must be taken of the different kinds of food in order to obtain a sufficient supply of nitrogenous elements.

The Quality of Food.—Man, like other animals, is made of what he eats; hence the German proverb is literally true, that "as a man eateth, so is he," and we may well credit the assertion of an eminent author that the general tendency of thought in any nation may be determined by the character of the national diet. True as this principle is when applied to the body in general, it is especially true as referring to the stomach. No organ is so directly and so profoundly affected by the quality of the food as the stomach.

Bad Cookery.—The real object of cooking is to render the elements of food more digestible. It is intended, indeed, to be a sort of partial preliminary digestion of the food; but the numerous devices of cooks and caterers,—complex compounds and indigestible mixtures, —have so far subverted the original design of the process as to render cooking a means of making food indigestible as often as otherwise. Altogether too little attention is paid to the subject of cookery as a science. In the majority of cases the task of preparing food for the palate—the stomach is seldom thought of—is intrusted to ignorant servant girls or colored cooks who compound mixtures by "the rule of thumb," and without any reference whatever to the physiological wants of the body. We are glad to see a slight indication of reform in this direction in the establishment of schools of cookery in the larger cities, and lectureships on the subject in some of our female seminaries. To become a good cook requires as much native genius and far more practical experience than to become a musician or a school-teacher, or even to enter some of the learned professions. The position of cook ought to be made so respectable and lucrative that it will attract persons of sufficient mental capacity and culture to make the art subservient to the purposes for which it was first employed and designed. A poor cook in a family is a worse enemy to the health, the comfort, and even the morals of the household, than would be a swamp generating malaria a half-mile away, a cesspool fever-nest at the back door, small-pox across the street, or a Chinese Joss-house in the next block.

Fried Food.—Of all dietetic abominations for which bad cookery is responsible, fried dishes are the most pernicious. Meats, fried, fricasseed, or otherwise cooked in fat, fried bread, fried vegetables, doughnuts, griddle-cakes, and all similar combinations of melted fat with other elements of food, are most difficult articles of digestion. None but the most stalwart stomach can master such indigestibles. The gastric juice has little more action upon fats than water. Hence, a portion of meat or other food saturated with fat is as completely protected from the action of the gastric juice as is a foot within a well-oiled boot from the snow and water outside. It is marvelous indeed that any stomach, under any circumstances, can digest such food, and it is far from remarkable that many stomachs after a time rebel.

It is principally for this same reason that "rich" cake, "shortened" pie-crust, and pastry generally, as well as warm bread and butter, so notoriously disagree with weak stomachs, and are the efficient cause in producing disease of the digestive organs. The digestion of the food being interfered with by its covering of fat, fermentation takes place. The changes occasioned in the fat develop in the stomach extremely irritating and injurious acids, which irritate the mucous membrane of the stomach, causing congestion, and sometimes even inflammation.

Uncooked Food.—Raw food, and food which is insufficiently cooked, is a frequent cause of indigestion. This is especially true of uncooked vegetables. Man is naturally a frugivorous animal, and is able to make use of vegetables and many grains as food only by the aid of cookery. The starch of vegetables is much more difficult of digestion than is that of fruits. All starch, in fact, is much easier of digestion if subjected to the action of heat before being eaten. By the action of heat, the starch granules, which consist of the starch proper inclosed in little capsules, are ruptured, and thus the digestive juices can readily come in contact with and digest the starch. When starchy substances are eaten raw, extra work is laid upon the organs of digestion, and indigestion follows. It is for this reason that raw fruit and green vegetables occasion so much disturbance of the stomach and bowels, these immature foods containing large quantities of starch in a very indigestible state. By cooking, unripe fruit and vegetables may be in a great degree deprived of their injurious properties. In Scotland, the eating of oatmeal imperfectly cooked is a very common

practice, the result of which is an almost universal suffering from a peculiar form of indigestion due to it. Nearly all kinds of food are much more easy of digestion after cooking than before, providing the cooking is performed in the proper manner. For vegetables and grains, cooking is especially necessary.

Decayed Food.—Much harm comes from eating food which has made appreciable advancement in the direction of decay. This is true of both vegetable and animal food. By the process of decomposition, poisonous elements are developed in animal and vegetable substances which do not naturally exist there. If decomposition is far advanced, these poisons may exist in such quantity as to produce immediate ill effects, sometimes occasioning death in a few hours. Instances of this sort have often occurred from eating canned meats which had spoiled, or which had been kept for a short time after opening. The practice in vogue in some countries, and to some extent in this, of keeping meat for some days before eating, so as to give it tenderness and a "high" flavor, is a most pernicious one. Better far, for health, is the horrible Abyssinian custom of eating the flesh while still warm and quivering.

For persons with slow digestion, such food is especially bad, since digestion is so slow that decomposition is not corrected, as it is to some extent in a healthy stomach, by the gastric juice, but is allowed to continue with all its serious consequences. If no immediate effects are seen to follow the use of such food, the poisons generated may be absorbed and appear in some later form analogous to blood poisoning. The stomach of a hyena may be able to digest the putrid flesh of a decaying carcass; but man's stomach was not intended for scavenger use, and requires fresh, untainted food.

Soft Food.—The structure of man's teeth indicates that he was intended to employ a diet consisting of food with sufficient consistency to require vigorous mastication. His jaws are armed with thirty-two strong teeth, compactly arranged in his mouth in such a manner as to make them most available for use. Obeying the general law governing all organized structures, by which organs develop or degenerate according as they are used or allowed to remain inactive, the teeth retain their health if vigorously employed in the mastication of solid food, but rapidly undergo decay when not thus used. This is well seen in cows which are fed on "distillery slops." The teeth of such animals decay and drop out for want of use, while those of cattle which keep their teeth actively employed in chewing the cud, are preserved intact. The same is true of

human beings. Eating soups, gruels, and other soft food, to the exclusion of articles requiring mastication, ruins the teeth at the same time that it disorders the stomach through the taking of too much fluid, and deficient insalivation.

Too Abundant Use of Fats.—Unfortunately for the poor stomach, the opinion prevails almost everywhere that food made "rich" with fat is the most nourishing. Undoubtedly, fat is an element of nutrition, and can be digested and assimilated when taken in proper quantities and in a proper manner; but the excessive use of fats of various kinds—lard, suet, butter, and other animal and vegetable fats or oils—is a prolific cause of certain forms of indigestion, especially that known as bilious dyspepsia. Eminent physiologists determined by careful experiment many years ago the fact that the large use of fats greatly lessens the biliary secretion, the quantity of bile being diminished in some instances to a very small fraction of the amount secreted when only pure water or food containing little fat was taken. When it is remembered that the bile is an essential element for the digestion of fat, it will be seen that a diminution of this digestive fluid, in connection with the taking of an extra quantity of oleaginous matter, is a most unfortunate circumstance, since it is thus absent when most needed. This fact sufficiently well accounts for the distressing symptoms which accompany the excessive use of fats by those whose digestion has been already weakened by abuse of this sort. The diminished quantity of bile eliminated by the liver is also sufficient cause for the condition established by the over-use of fats, vulgarly known by the expressive term, "bilious.". The elements which ought to be eliminated from the system are retained, clogging the vital machinery, and giving rise to the many unpleasant symptoms enumerated hereafter in describing "bilious dyspepsia."

If fats are to be used at all, it is much preferable to employ them cold, as butter taken on bread at the table, rather than cooked in the food, by which the fat elements permeate and render difficult of digestion the whole mass of food.

The Use of Sugar in Excess.—While sugar, like fat, is a true alimentary principle, capable of aiding in the maintenance of life when employed with the other elements of food, used in excess it becomes a serious source of disease. Employed alone, it is utterly incapable of supporting the vital activities of the body, being, in this respect, analogous to starch, its food equivalent. The popular idea that

sugar nourishes the nerves or the brain, makes the teeth sound, and is both harmless and wholesome, is quite a mistake, as many an innocent little one whose fond parents shared in the general error, has found out to the regret and sorrow of his friends.

The different forms of sugar, molasses, sirup, treale, honey, etc., are essentially the same in their effects, except that molasses and honey sometimes contain peculiar elements which to some persons seem to be almost active poisons. This is especially true of honey.

The injury from the use of sugar, or other saccharine substances, is occasioned, first, by the readiness with which it undergoes fermentation when subjected to warmth and moisture. In the stomach it finds all the conditions necessary for inducing fermentation; and were it not that saccharine substances in solution are usually so quickly absorbed that it is difficult for the chemist even to detect their presence in the stomach, this change would always occur. When a larger quantity is taken than can be absorbed promptly, or when taken in such form as to make ready absorption impossible, as in the form of preserves and sweet-meats of various sorts, acid fermentation does occur, and with serious results not only to the stomach, but to the whole system. The fermentation set up not only develops acids and gases from the sugar, but, being communicated to the other elements of the food,—the starch, and especially the fatty elements,—still worse forms of fermentation or decomposition occur, and the food is thus rendered unfit to nourish the body, while the mucous membrane of the stomach and intestines is irritated by the contact of unnatural, corroding elements in the food; and through their absorption, the whole system becomes affected.

The excessive use of sugar also greatly overtaxes the liver, which has an important part to act in its digestion, distracting it from its legitimate function, and thus leaving the elements which it ought to eliminate, to accumulate in the system. Thus an individual may become "bilious" from the over-use of sugar as well as from excess in the use of fats.

Condiments.—By condiments are meant all substances added to food for the mere purpose of rendering it more palatable, though possessing no positive nutritive value in themselves. Mustard, vinegar, pepper, cinnamon, and various other spices, are included in this category, together with salt, although the last-named article is by some held to be of the nature of a food, supposing it to supply some want in the body.

Mustard, pepper, pepper-sauce, cinnamon, cloves, cardamoms, and similar substances, are of an irritating, stimulating character, and work a twofold injury upon the stomach. By contact, they irritate the mucous membrane, causing congestion and diminished secretion of gastric juice when taken in any but quite small quantities. This fact was demonstrated by the observations of Dr. Beaumont upon St. Martin. After several years' careful study of the relations of various foods, drinks, etc., to the stomach, Dr. Beaumont stated in summing up his experiments that "stimulating condiments are injurious to the healthy stomach." He often saw congestion produced in the mucous membrane of St. Martin's stomach by eating food containing mustard, pepper, and similar condiments.

When taken in quantities so small as to occasion no considerable irritation of the mucous membrane, condiments may still work injury by their stimulating effects, when long continued. The stomach, being at first excited to more than natural activity, afterward suffers from reaction, and is left in an inactive, diseased state, incapable of secreting sufficient gastric juice to supply the needs of the system in digesting food. This final result is often averted for some time by increasing the quantity of the artificial stimulus, in the form of pepper, mustard, salt, etc., but nature gives way at last, and chronic disease is the result.

In the case of salt, there are several further objections to be urged, which are at least cogent against its excessive use; and by excessive use we mean a quantity which causes thirst either at or after meals, occasioned by the feverish state of the stomach induced by the caustic properties of the saline element.

1. Salt is antiseptic. As already seen, anything which prevents fermentation will interfere with the action of the gastric juice. Hence salt, in any except very small quantities, must materially interfere with digestion.

2. It is an irritant, not only to the stomach but to other parts of the system as well, as is indicated by the quickened pulse, thirst, and other symptoms of a febrile character experienced by a person after taking a slightly larger quantity than usual.

3. Being a purely mineral substance, in no degree prepared, by association with organized life in plants, for assimilation as is necessary in the case of all mineral substances, it is exceedingly doubtful whether it is a food in the sense that fruit, vegetables, grains, or their

several nutritive elements, are foods, and whether it can be assimilated or made to take part in the vital processes of the body in any way, in larger quantities than it is found in food.

4. Experimental evidence shows that human beings, as well as animals of all classes, live and thrive as well without salt as with it, other conditions being equally favorable. This statement is made with a full knowledge of counter arguments and experiments, and with abundant testimony to support the position taken.

We may, in conclusion, remark that though we do not, except in rare instances, advise the entire discontinuance of the use of salt, on account of its having been so long employed as an ingredient of food, we believe that it may be greatly reduced in quantity by all who use it, without detriment, and with real benefit. The manner in which it is treated by the system, being retained in the blood instead of being deposited in the solid tissues to any extent, and washed out through the skin, mucous membrane, kidneys, and liver, and thus rapidly eliminated in proportion to the quantity taken, is at least a hint that a very large amount is not needed.

Salted food is generally known to be very hard of digestion, and when it is taken for a long time, the stomach often fails. A piece of fresh fish which will digest well in one hour and a half, requires four hours after salting, according to Dr. Beaumont.

Pickles.—Cucumbers, peaches, green tomatoes, and numerous other fruits and vegetables, are sometimes preserved by saturation with strong vinegar. Sometimes whisky or some other alcoholic liquor is added to increase the preservative property of vinegar. The same process which makes it impossible for a fruit or vegetable to ferment or decay, makes its digestion equally difficult, as already explained. Pickles are exceedingly unwholesome as articles of food, and often cause acute dyspepsia in those who eat of them. Young ladies addicted to the free use of pickles may be assured that they must certainly part with their favorite dainty or bid farewell to good digestion. Cucumbers preserved with salt or vinegar are next to impossible of digestion. The proverbial unhealthfulness of this vegetable is a popular notion based on experience with the article prepared with vinegar and salt. Those chemical agents harden the delicate structures of the vegetable, and render it almost unapproachable by the digestive juices. The pure vegetable, unsophisticated by condiments, is as harmless as other green vegetables. We would not hesitate to eat it freely thus, if need be, and in "cholera times."

Vinegar.—As the use of vinegar is continually increasing, attention should be called to the fact that it may be a cause of disease. Ordinary vinegar contains about five per cent of acetic acid, its principal ingredient. Like alcoholic liquors, vinegar is a product of fermentation, being the result of carrying a little farther the same process by which alcohol is produced. Vinegar is much more irritating to the digestive organs than an alcoholic liquor of the same strength. It is extremely debilitating to the stomach when much used, though for the time being exciting. Vinegar is not infrequently employed in considerable quantities by young ladies who are anxious to look pale and interesting, and it never fails to produce the desired effect. It can be well recommended for such a purpose, since it so greatly impairs the digestion as to soon interfere seriously with nutrition. The moderate use of a light wine or of ale or beer is much less destructive to the digestive organs than the large use of vinegar which is not uncommon among hearty eaters. There is really no need of resorting to so inferior a source for a mild acid, as we have the want met most perfectly in lemons, limes, citrons, and other acid fruits. As a dressing for some kinds of vegetable food, lemon juice is a perfect substitute for vinegar.

We have maintained this position respecting the use of vinegar for several years, notwithstanding it has been highly recommended by not a few eminent writers on food and dietetics. Very recently, however, M. Richet, at the head of an august body of French savants, comes forward maintaining that by careful experiment he has proved that these things are "bad food for the stomach." He does not hesitate to pronounce vinegar and tartaric acid prolific causes of dyspepsia, and highly condemns the use of vinegar and pickles by young ladies. It is no wonder that young ladies who indulge in these unwholesome articles of food grow "pale and interesting" with dyspepsia. According to M. Richet, the use of acetic and tartaric acids causes a decrease in the secretion of gastric juice, without which no digestion can take place.

Tea and Coffee.—In classing these favorite beverages with causes of dyspepsia, we shall certainly call forth a loud protest from the numerous devotees of "the fragrant cup;" and among the number of those who argue for their use we shall find numerous learned professors, as well as nearly the whole sisterhood of the wives, maidens, mothers, and grandmothers of the nation, along with a good proportion of the husbands, fathers, brothers, and grandfathers as well. Nevertheless, it can

be easily shown that whatever action may be assigned to these beverages, it is unfavorable to digestion, rather than otherwise. Leaving out of consideration the objections which may be urged against the use of tea and coffee on other grounds, the following may be offered as reasons why they are objectionable on account of exerting an injurious influence upon the digestive organs:—

1. Both tea and coffee contain an element resembling tannin, which precipitates or neutralizes the pepsin of the gastric juice, and so weakens its digestive power.

2. Theine and caffeine, the active principles of tea and coffee, are toxic elements which at first increase and then diminish vital action, thus occasioning debility of the digestive organs from long-continued use.

3. Both tea and coffee are objectionable on the same ground as other beverages in connection with meals, on account of disturbing the digestion by dilution and consequent weakening of the gastric juice, and overtaxing the absorbents, delaying the digestion of the food and thus giving rise to fermentation. When taken hot, as is the usual custom, these beverages, as do others, at first stimulate but ultimately relax and debilitate the stomach.

The objections mentioned as applying to tea and coffee may be urged with equal force against cocoa and chocolate, the effects of which differ from the effects of tea and coffee chiefly in degree.

For the other injurious effects of tea and coffee, see chapter on "Stimulants and Narcotics."

Alcohol.—We have not space in this connection to dwell at length upon the damaging effects of alcohol upon the human system, nor in full detail of its effects upon the stomach. The following facts, however, are well worth the consideration of those who believe in the use of alcohol either moderately or with greater freedom:—

1. Alcohol itself is an active poison, which when received into the stomach in a concentrated state is almost as quickly fatal to life as is prussic acid or strychnia. It precipitates the pepsin of the gastric juice, rendering it inert.

2. It irritates the gastric mucous membrane when taken in any but extremely small quantities, even beer and the weaker liquors having this effect when long continued.

3. The ultimate effect of alcohol is to cause degeneration of the secreting glands of the stomach, by which its utility as a digestive organ is destroyed.

Dr. Beaumont's observations on the effects of alcohol are very positive and distinct in their indications. St. Martin being an intemperate man, occasionally indulging freely in drink, Dr. Beaumont had an opportunity of observing the effects of its use, as he was able to look directly into his stomach by the aid of a strong light, through the window provided by the remarkable accident from which he had suffered. After he had been drinking freely for several days, Dr. Beaumont found the mucous membrane exhibiting inflamed and ulcerous patches, and the secretions very greatly vitiated, the gastric juice being diminished in quantity, viscid and unhealthy, although St. Martin did not complain of any unusual feelings, his appetite being apparently unimpaired. The condition became still more aggravated for two days, when the Doctor found that "the inner membrane of the stomach was exceedingly morbid, the erythematic appearance more extensive, and the spots still more livid. From the surface of some of them exuded small drops of grumous blood; the aphthous patches were large and very numerous,—the mucous covering thicker than common, and the gastric secretions very greatly vitiated. The gastric fluids extracted were mixed with a large proportion of thick, ropy mucus, and a considerable muco-purulent discharge slightly tinged with blood, resembling the discharge from the bowels in some cases of dysentery."

It will be remarked that notwithstanding the very serious condition of his stomach, St. Martin was unconscious of any great disturbance there. This was partly due, no doubt, to the paralyzing effect of alcohol upon the nerves of sensibility. It is owing to this fact that so many suppose that alcoholic drinks have no specially bad influence upon the stomach, when really their stomachs are well-nigh useless from disease but too insensible to indicate their condition.

Liquor of any sort taken upon an empty stomach is especially injurious.

Tobacco.—Not infrequently, though less often than is the case with alcoholic liquors, this narcotic drug is recommended as a remedy for dyspepsia. Nevertheless, in the case of tobacco as in that of alcohol, the remedy suggested is itself an active cause of stomach disease. Only on the *similia similibus* plan could either one be reasonably employed. Both smoking and chewing weaken and debilitate the digestive organs, though, both of these practices are thought by those who indulge them to stimulate the process of digestion, which they probably do for the time being but only at the expense of subsequent injury. Snuff-taking, especially,

produces gastric irritability, probably by reflex sympathy of the mucous membrane of the stomach with that of the nasal cavity, which is irritated by the direct contact of the acrid drug.

The immense waste of saliva occasioned by chewing and smoking may fairly be considered as one of the means by which the system sustains loss and injury through the use of tobacco. Those who chew or smoke to prevent excess of fat, should understand that any drug which will exert such an influence upon the system must be a powerfully destructive agent. Those who succeed in keeping down fat by the use of tobacco may depend upon it that they are doing so only at the ruinous expense of their digestive organs, and may look forward with certainty to the breaking down of their nervous systems.

Hard Water.—So little attention has been paid to this really common cause of indigestion by writers on this subject, that we cannot forbear mentioning it here. Experience has often proved that the use of hard water impairs the integrity of the stomach sooner or later when long continued; and in numerous instances its effects are almost immediate upon persons who visit a hard-water district, having been accustomed to the use of soft water. These injurious effects are undoubtedly attributable to the lime and magnesia which are contained in water called hard. These alkalies, as already seen in considering the physiology of digestion, neutralize the gastric juice, and thus work their mischief. There is little necessity for the use of hard water in any part of the country. Where there are not soft-water wells or springs, rain-water may be caught and preserved in cisterns, and by filtration through carbon filters it can be made pure and palatable for drinking and cooking purposes. There is no foundation for the theory that hard water is in any respect more excellent for use than pure soft water.

Alkalies.—Soda, saleratus, and the numerous compounds of these substances with ammonia, alum, cream of tartar, etc., are all objectionable on the same grounds as hard water. Being alkaline, they antagonize the action of the acid gastric juice, and thus weaken digestion. There is no more active dyspepsia-producing agent than soda and saleratus biscuit, one of the most common articles of food to be found on the tea-table of rich and poor in this country. Doubtless, well-prepared baking-powders are much preferable to soda and cream of tartar or saleratus and sour milk, mixed by the cook in accordance with the not remarkably accurate "rule

of thumb," through which bungling chemistry the biscuit often present a golden hue which may be attractive to the eye, but gives to the tongue quite too distinct a flavor of soda and potash to be agreeable to a fastidious taste, to say nothing of the probable effect upon a stomach not impregnable against the attacks of chemical agents. In baking-powders, the various ingredients are so mixed as to leave nearly neutral products, and yet these compounds are scarcely less pernicious in their influence upon digestion than the original chemicals from which they are formed. We deem the wide-spread and growing use of these chemical bread-making agents bad omens for the digestion of the next generation; though we readily grant that if the alternative is between heavy bread and bread made "light" with baking-powder, the latter is preferable.

Perverted Appetites.—Strangely perverted tastes, as shown in a fondness for earthy and other inorganic or innutritious substances, while sometimes the result of dyspepsia, are often the cause of stomach disorders, being the result of nervous or mental disease, or being adopted as a habit through example. In South America there are whole tribes of human beings who habitually eat considerable quantities of a peculiar kind of clay. Several North American tribes have the same habit, being known as clay-eaters. A similar propensity sometimes appears among more civilized human beings, being almost exclusively confined, however, to young women, chiefly school-girls, who acquire the habit of chewing up slate pencils, and gradually become so fond of such earthy substances that they have in some instances been known to eat very considerable quantities of chalk, clay, and similar substances. While indicating a depraved state of the system, and often of the mind also, this practice has a very pernicious effect upon the stomach, which is not intended, as is that of the fowl, to receive inorganic matter of that sort.

The amount of abuse of this sort which the stomach will stand, however, is quite astonishing. Dr. Pavy tells a story of an American sailor who saw a juggler pretending to swallow pocket-knives. With the characteristic recklessness of a sailor, and supposing that the knives were really swallowed, he attempted to do the same thing himself, and succeeded in getting down four. Three of these were passed off in two days, but he never saw the other. Six years after, he swallowed fourteen knives in two days, and was taken to a hospital, where "he got safely delivered of his cargo." He was not so

fortunate on a subsequent occasion, when he paid dearly for his folly, lingering in misery for some time until he died, when his stomach was found to contain a number of rusty knife-handles, blades, springs, etc., being greatly contracted and corrugated in consequence of the violence which had been done to it.

The habit of swallowing cherry pits, apple and other small seeds, is a very reprehensible one. Such objects not only disturb the stomach, but sometimes find lodgment in the appendix at the lower end of the cœcum, giving rise to inflammation and death. As a general rule, the innutritious parts of foods, as the skins of fruits and vegetables, the seeds and cores of apples, and similar parts, should be carefully separated from the nutrient portions and discarded.

Adulterations of Food.—The numerous adulterations of food which are now so extensively practiced must be recognized as a not unimportant cause of functional disease of the stomach. Alum in bread and in baking-powders; lead in drinking-water which has passed through lead water-pipes, or has been stored in lead cisterns, or collected from a roof covered with sheet-tin containing lead; lead occurring in the tin cans used for preserving fruit, or in tin pans or other tinned ware, or in the glazing of kettles; vinegar containing sulphuric and other strong mineral acids; pickles boiled in copper or brass vessels and thus poisoned with copper; sugar adulterated with glucose—or sugar made from corn, refuse starch, etc.—and containing iron, sulphuric acid, tin, etc.; flavoring extracts made by purely chemical processes, and containing not a drop of the extract of the fruit after which they are named; chalk and water in milk,—these, with numerous other equally harmful adulterations, work havoc with the stomachs of people who are so unfortunate as to be victimized.

Unseasonable Diet.—The failure to recognize the necessity of adapting the diet to the season and climate is a prolific source of a certain class of dyspeptic disorders. This is especially noticeable when the use of large quantities of carbonaceous food, especially fats and sugar, which may be used in the winter with comparative impunity, is continued into the warm season of the year, or when a diet of this sort is continued in a warm climate by persons who have been accustomed to it in a cold country. It is this sort of transgression of the laws of digestion that gives rise to "biliousness," "bilious dyspepsia," etc., in many persons. Large quantities of fat and sugar are not well tolerated by the stomach at any time; and in warm climates,

and the warm season of cold and temperate latitudes, they are exceedingly injurious.

Pressure upon the Stomach.—The stomach is remarkably sensitive to pressure. It even sometimes becomes temporarily paralyzed by excess in eating, or by the accumulation of gas from fermentation, by the distension of its walls. It is equally liable to injury of a similar sort from external causes. A sudden blow upon the stomach has been known to produce almost instant death. In ladies, the wearing of corsets, and tight-lacing with or without the corset, are common causes of dyspepsia as well as of other serious diseases. Wearing of the pantaloons drawn tightly, and without suspenders, has a similar effect in men. The soldiers of the Russian army once suffered so much from this cause that it became necessary to correct the evil by a royal edict for the purpose. Very soon after the evil practice was discontinued, the effects disappeared. Book-keepers and school children from sitting at a desk, seamstresses and tailors from stooping over at their work, shoe-makers, weavers, and washer-women, from direct pressure upon the stomach incidental to their work, suffer from disturbance of that organ.

Drugs.—The continued use of drugs of several sorts, and especially of patent medicines, "bitters," and "purgatives," particularly the latter, has a very damaging effect upon the stomach and bowels. Too much cannot be said to discourage the use of laxatives, purgatives, "liver pills," etc. While sometimes beneficial, agents of this sort, if used for any length of time, are quite certain to work mischief. Purgatives should never be used except as temporary palliatives. If the bowels require artificial aid, the enema is far preferable; and yet this plan also has its inconveniences, and results badly if too long continued. In general, the less drugs one takes the better. Patent nostrums should be shunned as the most virulent poisons, which in many instances they are.

Neglect of the Bowels.—Neglecting to heed the calls of nature promptly and regularly is an abuse of the digestive organs which should not be overlooked. The bowels are as much a part of the alimentary canal as is the stomach; and they have an important part to act in absorbing the digested food. They are also important excreting organs, some of the worst poisons generated in the system passing off through them. The feces are made up, not chiefly of the remains of food, as many persons suppose, but of impurities thrown out of the

system by the intestinal mucous membrane. When these excrementitious substances, the foulest in the body, are retained, they are to some extent reabsorbed, thus poisoning the system. Every physician is familiar with the peculiar fecal odor of the breath of a costive child, an evidence of the absorption referred to.

The bowels naturally move once a day with most people, and commonly soon after breakfast. A few persons habitually move their bowels only every other day, without injury, while some persons find it necessary to relieve the bowels twice in twenty-four hours. However the habit may be, it should be regular. Every person should have a definite time for attending to the relief of the bowels as systematically and punctually as in taking meals. This is a matter of very great importance; piles, or hemorrhoids, fissure and fistula, prolapsus of rectum and also of the womb, and a host of other evils, begin in constipation of the bowels.

To encourage the needed regularity and promptness in attending to the bowels, it is important that comfortable accommodations for the purpose should be provided. The custom of building a small, loose shed at a considerable distance from the house is a bad one, as it subjects women and children, especially, to unpleasant and even dangerous exposure during the cold months of the year. Still more to be deprecated is the custom, quite prevalent in the West, of dispensing with privy accommodations altogether. The closet should be near the house, and should be made warm and convenient, and properly screened. If judiciously taken care of, it need not be a nuisance or a cause of disease, even if adjoining the house or within it. The earth-closet plan is an excellent arrangement for winter.

A very eminent medical gentleman, a man of long experience as a specialist in the treatment of diseases of women, affirms his belief that not a few of the serious maladies from which women suffer are due to neglect of the bowels.

The best remedies for constipation are given under the proper head.

Mental Influence.—The digestive process is very greatly under control of the mind. The connection between the mind and the stomach is so intimate that Van Helmont maintained for a long time that the stomach was the seat of the soul. By any strong emotion the whole digestive apparatus may suddenly cease to act. Fear, rage, and grief check the salivary secretion, and without doubt the gastric

also. Through the mind, the appetite may be either encouraged or quite destroyed.

A man who sits down to his dinner with his mind depressed with business cares, the embarrassment of debts, or the anxiety of doubtful speculations, cannot hope to digest the most carefully selected meal. The woman who dines with her mind disturbed with discontent, fretfulness, and worriment, is certain to suffer with indigestion. Domestic infelicity may well be counted as at least an occasional cause of digestive derangements. Meals eaten in moody silence are much more apt to disagree with the stomach than those which are accompanied by cheerful conversation. A hearty laugh is the very best sort of condiment. Cheerfulness during and after meals cannot be too highly rated as an antidote for indigestion.

Hygiene of the Teeth.—Defective teeth, by interfering with the complete and thorough mastication of food, seriously impair the digestion. On the other hand, impairment of digestion, and perversion of the secretions, is a very common cause of decay of the teeth. Thorough mastication is essential to good digestion; and no one can hope to preserve a good digestion while munching food with toothless gums, or subsisting on a dietary that requires no use of teeth.

So rapid is the increase of degeneration of the teeth in modern times, that we have asked ourselves more than once the question, Will the American race become toothless? Not quite, perhaps; at least not so long as artificial dentures can be manufactured from such a variety of substances and made to answer so useful a purpose as masticators. Indeed, some people already afford two sets of teeth—a set for every day, for rough usage, and an extra-fine set for exhibition on special occasions. But at the present rate of deterioration, not many more generations will appear before we shall find a toothless race, shipwrecked in health, with digestion bankrupt, and "nerves" the dominant feature.

Rarely indeed, do we find a person at thirty years of age with a set of sound teeth. Far more often do we find young lads and girls of ten to sixteen years of age whose teeth are mere shells of decaying tissue, rotting away with almost visible rapidity, depositories of decaying particles of food, and millions of wriggling animalcules, and the sources of contaminating elements which deteriorate digestion, and of offensive odors which contaminate the breath. In confirmation of these statements respecting the condition of American masticators

it may be mentioned that there are 12,000 dentists in the United States, who annually extract twenty million teeth, manufacture and insert three million artificial teeth, and hide away in the cavities of carious teeth three tons of pure gold, to say nothing about the tons of mercury, tin, and other metals employed in "fillings."

For the preservation of the teeth we offer the following rules, which, if thoroughly carried out, will certainly secure good results unless the teeth are ruined by incurable constitutional disease:—

1. See that the teeth are properly developed. To this end, supply the child while an infant, and even after, with an abundance of food which is rich in "salts," such as peas, beans, graham bread, oatmeal, and the like, and carefully watch the first set of teeth as they are developed and give place to the permanent set.

2. Have a tooth filled as soon as the smallest appearance of decay is discovered; and in order to discover the very beginnings of decay, examine them frequently, or have a dentist do so. If a child complains of toothache, take him to a good dentist at once, for something is certainly wrong. It is a mistake to suppose that it is not worth while to have first teeth filled, since others will come in their place. Unless the tooth is about to be displaced by the permanent tooth, it should be filled, for the benefit of the coming permanent tooth as well as for the present health and comfort of the child.

3. Cleanse the teeth night and morning, as well as after each meal, taking care to remove all particles of food, brushing and rinsing well. Use soap and powder at least once a day. Give attention to the back teeth, and the inside as well as the front teeth, which are apt to receive chief attention for the sake of appearance, when they need the least.

4. Never allow mineral acids of any kind, nor such preparations as chloride or sulphate of iron, to touch the teeth, as they will destroy the enamel.

5. Avoid allowing gritty substances to come in contact with the enamel, as they will scratch and mar it, and perhaps cause the beginning of decay.

6. If possible, never lose a tooth. An eminent physician once said that we lose a year of life every time we part with a tooth. They are too valuable to lose when by a trifling expense they may be saved.

7. Never employ traveling dentists nor purchase or use patent compounds for the teeth. Many of them contain substances which will destroy the enamel or induce disease of the gums.

8. Never carry "old stumps" in the mouth. If they cannot be filled, have them extracted. Nothing is much more repulsive than a mouth full of stumps of rotten teeth. We would much rather encounter the decomposing carcass of a dead dog than a person with such a mouth; for we could easily run away from the former, but might be compelled to tolerate the presence of the latter notwithstanding the nuisance.

9. If the teeth are utterly in ruins and can in no way be repaired so as to make them really serviceable, they should be replaced by good artificial teeth. It should be borne in mind, however, that the natural teeth are much superior to any artificial substitute; and hence they should not be sacrificed without making all possible efforts to save them. Many times dentists advise the drawing of teeth for the purpose of securing the opportunity to make a new set; hence it is important that advice should be sought from a skillful and trustworthy source.

10. Artificial teeth must be cared for with as much scrupulous regularity and thoroughness as natural teeth in order to preserve the health of the mouth. They should be removed from the mouth at night and placed in a glass of water, and in the morning should be thoroughly cleansed with fine soap or with a solution of chlorinated soda, which can be obtained of any druggist. Artificial dentures should also be removed from the mouth and thoroughly cleansed after each meal.

SECRETION AND EXCRETION.

The nutrition or maintenance of the body in health, involves two essential processes, *assimilation* and *disintegration*, or *dis-assimilation*. *Assimilation* is the process by which the nutritive material furnished to the tissues in the blood is made into tissue, each tissue possessing the power to renew itself from the elements found in the blood. *Dis-assimilation* is the process of tissue waste or breaking down. Every act, thought, sensation, no matter how slight, results in the waste or breaking down of tissue. As accessory to these two great processes, we have *secretion* and *excretion*. *Secretion* is the formation from the blood of something which did not exist in it, but which is produced by transformation of some of the elements which it contains, for the purpose of aiding in some vital process. Assimilation is really a secretory process, each tissue possessing the power to secrete tissue like itself. *Excretion* is the removing from the blood of the products of tissue waste which are washed out of the tissues by the venous blood.

Secretions.—The principal secretions are the following: 1. The digestive fluids, comprising the *saliva, gastric juice, bile, pancreatic juice,* and the *intestinal juices,* all of which have been described; 2. *Serous fluids,* produced by serous membranes for the purpose of lubrication; as by the peritoneum, which lines the abdominal cavity and covers the intestines; the pericardium, which incloses the heart; the pleura, which covers the lungs and lines the chest; the membranes of the brain, etc.; 3. *Synovial fluid,* which is formed by the synovial membranes of joints for the purpose of lubrication; 4. *Sebaceous matter,* which is formed by minute glands in the skin and some parts of the mucous membrane for the purpose of protecting the skin, and keeping it in a supple condition; 5. Various other fluids formed by small glands which are imperfectly understood, as the pineal gland and pituitary body of the brain.

Excretions.—The principal excretory products are the *sweat, mucus, urine, bile,* and carbonic acid, eliminated respectively by the skin, the mucous membrane, the kidneys, the liver, and the lungs. The excretions are not produced by the organs named, but by the tissues, the

organs mentioned simply serving to separate the various morbid elements from the blood.

Without going into the minute details of the subject, we will now consider the structure and functions of the principal secreting and excreting organs which have not been already described.

The Skin.—The general structure of the skin has been described in connection with the consideration of the sense of touch (see page 166), and hence we need consider here only the points there omitted; viz., the secreting and excreting organs of the skin, and the hair and nails. A reference to PLATE IV will give quite a clear idea of the relations of the sweat glands, the hair, and the sebaceous glands, to the general framework of the skin. The area of the skin in an adult is twelve to sixteen square feet.

The Sweat Glands.—A close examination of the little ridges found upon the palms of the hands, by the aid of a small magnifying-glass, will reveal what appear to be fine transverse lines crossing the ridges at short intervals. A closer inspection shows that the apparent lines are really extremely minute openings, guarded by delicate valves. These are the mouths of the perspiratory ducts, which convey to the surface the product of the sweat glands. The gland itself is merely a coiled tube, situated deep down in the true skin, and surrounded with a net-work of blood-vessels. The duct is simply a continuation of the same tube upward through the cuticle to the surface. It passes out upon the surface of the skin obliquely, thus leaving a small portion of the cuticle overlapping its orifice, forming a sort of valve.

The number of these delicate glands is enormous. It has been carefully estimated to be about 2,300,000 in a single individual. The length of each is about one-fifteenth of an inch, making their aggregate length about two and one-half miles.

Between two and three pounds of sweat is thrown off each day. The perspiratory secretion consists of water holding in solution various excretory principles, the chief of which is urea, which is also eliminated by the kidneys, and is one of the most important excretory products. The amount of urea varies somewhat with the amount eliminated by the kidneys. The sweat also contains a large proportion of chloride of sodium. In certain parts of the body, particularly the armpits and between the toes, the sweat glands are more numerous than in most other parts, and the perspiration often has a peculiar and offensive

odor. The sweat secretion is usually acid; but when so strongly odorous it is found to be alkaline.

The Hair.—With the exception of the palms of the hands and the soles of the feet, the whole surface of the body is covered with hairs, which vary much in length and thickness in different parts of the body. The majority are soft and fine, those upon the head and a few other parts of the body being long and silky. The hairs found upon the head average about $\frac{1}{400}$ of an inch in diameter, varying from $\frac{1}{140}$ to $\frac{1}{1500}$ of an inch. Dark hair is usually coarser than light. The color of the hair is due to pigment of the same nature as that which gives color to the eye and skin. The number of hairs upon the entire head is about 120,000. Straight hairs are nearly round. That which is curled is elliptical. The hair of the negro is flat. Hair possesses the peculiar property of becoming strongly electric when rubbed. This is especially manifested in cold, dry weather. When combed in the dark, sparks may be seen to issue from it. This may be well seen in rubbing the back of a cat, stroking toward the head.

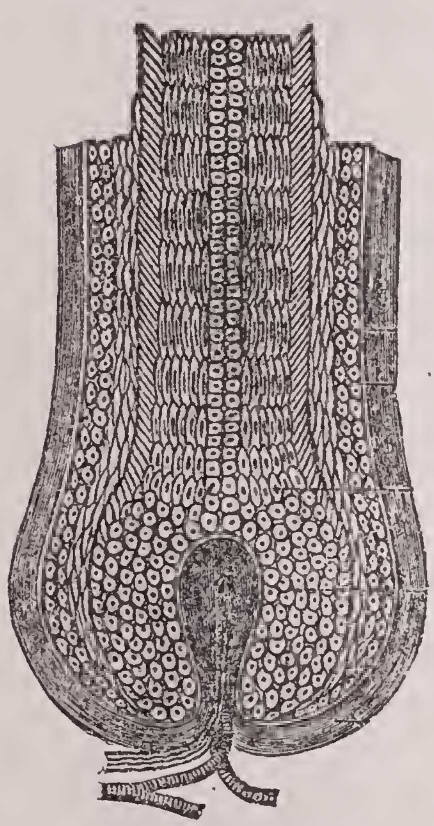


Fig. 130. The Root of a Hair, showing nutrient blood-vessels at the base.

Most hairs are hollow, being really hollow tubes, the outside being covered with a layer of overlapping cells. When viewed with a microscope, the hair looks rough and serrated. This peculiarity can be demonstrated by a simple experiment. Place two hairs between the thumb and finger with the roots the same way. Now make a slight side movement with the thumb and finger, thus rubbing the hairs alternately in different directions. Two smooth wires so treated would remain in the position in which they were placed; but the hairs will be seen to move with each alternate movement of the fingers, and always toward the root. Now if one hair be changed so that its root is in the same direction as the tip of the other, the same rubbing will cause them to move in opposite directions.

The hairs grow from little pouches in the skin. The root of a hair greatly magnified is shown in Fig. 130. The hair serves a useful purpose in

protecting the body, giving additional warmth in some places, and in hot climates protecting the head from the heat of the sun, being a good non-conductor. It also diminishes the friction of clothing. The mustache protects the lungs from dust.

Connected with each hair follicle is a little band of involuntary muscular fibres, one end of which is attached to the follicle, the other to the skin near by. Under the influence of cold these muscles contract, puckering the skin and producing the peculiar appearance known as goose-flesh.

Sudden Blanching of the Hair.—Cases have occurred, in which, under the influence of fear, grief, or some other strong emotion, the hair has turned white in a single night, a week, or some other short period. Examination of hair thus affected has shown that the cause of the change of color is the appearance in the hair of great numbers of minute air-bubbles.

The Sebaceous Glands.—Connected with the hair follicles are little glands for the secretion of a fatty substance. These glands discharge their contents into the hair follicles, whence they reach the skin.

The Nails.—These are horny plates which grow from a fold of skin near the ends of the fingers and toes. They are formed in a manner much similar to that in which the hairs are produced. Their object is to protect the ends of the fingers and toes.

Functions of the Skin.—The skin performs a number of very important offices for the body. Perhaps the most important is that of excretion. Each of its millions of sweat glands is actively and constantly engaged in separating from the blood impurities which would destroy life if retained. These foul products are poured out through a corresponding number of minute sewers, and deposited upon the surface of the body to the amount of several ounces each day, or several pounds, if the whole perspiration be included in the estimate, as is commonly done.

The skin is also an organ of respiration; it absorbs oxygen, and exhales carbonic acid gas, with other poisonous gases. The amount of respiratory labor performed by the skin is about one-sixtieth of that done by the lungs. In some of the lower animals, the whole work of respiration is performed by the skin. In the common frog, the respiratory action of the skin and of the lungs is about equal.

Another important office of the cutaneous tissue is absorption.

The absorption of oxygen has already been referred to; but it absorbs liquids as well as gases, and to a much greater extent. By immersion in a warm bath for some time, the weight of the body may be very considerably increased. Dr. Watson, an English physician of note, reports the case of a boy whose weight increased nine pounds in twenty-four hours, solely by cutaneous absorption of moisture from the air. This extraordinary action was occasioned by disease. Seamen, when deprived of fresh water, quench their thirst by wetting their clothing with sea-water, the aqueous portion of which is absorbed by the skin. The lymphatic vessels are believed to be the principal agents in absorption.

Another remarkable function of the skin is the regulation of temperature. By its density and non-conducting property it prevents the escape of necessary heat to a considerable degree. But when the amount of heat generated in the body becomes excessive, either from abnormal vital activities, or by exposure to external heat, the skin relieves the suffering tissues by favoring the escape of heat. This desirable end is attained through the evaporation of the moisture poured out upon the surface by the perspiratory glands.

It has been estimated that the evaporation of water from the cutaneous surface and from the mucous membrane of the lungs occasions the loss each minute of sufficient heat to raise a pint of water 100° F. in temperature. This is certainly a powerful cooling process.

Lastly, we mention as a further function of the skin, and one which is not the least in importance, its utility as a sensitive surface. It is a well-established physiological fact that the mind is only a reflection of impressions received from without, or at least that its character is largely determined by the nature of the impressions made upon its organs of sensibility. The skin is the organ of touch, and of the various modifications of tactile sensibility. It is the most extensive organ of sensibility in the body, and is very closely connected with all the great nerve centers, so that it is perhaps the most efficient means through which to affect the general nervous system. Its intimate sympathy with internal organs is shown in the great number of diseases in which this organ evidently suffers on account of disability of some internal part.

The importance of the functions of the skin is shown by the fact that a person quickly dies when its action is interrupted. A coat of varnish or caoutchouc, applied over the whole skin, will kill a man al-

most as quick as a fatal dose of strychnia. In illustrative experiments, horses, dogs, and other animals have been killed by obstructing the action of the skin by some similar means. A little boy was once killed by covering him with gold-leaf to make him represent an angel at a great celebration.

The offensive odor of the perspiration, and the characteristic smell of the sweat-soiled under-clothing of a tobacco-user, are facts which well attest the value of the cutaneous functions in removing impurities from the body.

Cleanliness.—The skin is one of the most important depurating organs of the whole body. From each of its millions of pores constantly flows a stream laden with the poisonous products of disintegration. As the water evaporates, it leaves behind these non-volatile poisons, which are deposited as a thin film over the whole surface of the skin. As each day passes, the process continues, and the film thickens. If the skin is moderately active, three or four days suffice to form a layer which may be compared to a thin coating of varnish or sizing. The accumulation continues to increase, unless removed, and soon undergoes further processes of decomposition. It putrefies, rots, in fact, and develops an odor characteristic and quite too familiar, though anything but pleasant, being at once foul, fetid, putrid, pungent, uncleanly, and unpardonable.

But the offense to the nose is not the extent of the evil. The unclean accumulation chokes the mouths of the million little sewers which should be engaged in eliminating these poisons, and thus obstructs their work. Being retained in contact with the skin, some portions are reabsorbed, together with the results of advancing decay, thus repoisoning the system, and necessitating their elimination a second time.

Here water serves a most useful end if properly applied. It is unexcelled as a detergent, and by frequent application to the skin will keep it wholly free from the foul matters described. The necessity for frequent ablutions is well shown by the fact that nearly two pounds of a poison-laden solution, the perspiration, is daily spread upon the surface of the body. It is not an uncommon occurrence to meet with people who have never taken a general bath in their lives. Imagine, if possible, the condition of a man's skin, at the age of seventy or eighty years, which has never once felt the cleansing effects of a thorough bath!

One of the most serious effects of this accumulation of filth is the clogging of the perspiratory ducts. Their valve-like orifices become obstructed very easily, and depuration is then impossible. It is not wonderful that so many people have torpid skins. The remedy is obvious, and always available.

How to Make the Skin Healthy.—A man who has a perfectly healthy skin is nearly certain to be healthy in other respects. In no way can the health of the skin be preserved but by frequent bathing. A daily or tri-weekly bath, accompanied by friction, will keep the skin clean, supple, and vigorous. There is no reason why the whole surface of the body should not be washed as well as the face and hands. The addition of a little soap is necessary to remove the oily secretion deposited upon the skin.

A lady of fashion, in enumerating the means for preserving beauty, says: "Cleanliness, my last recipe (and which is applicable to all ages), is of most powerful efficacy. It maintains the limbs in their pliancy, the skin in its softness, the complexion in its lustre, the eyes in their brightness, the teeth in their purity, and the constitution in its fairest vigor. To promote cleanliness, I can recommend nothing preferable to bathing. The frequent use of tepid baths is not more grateful to the sense than it is salutary to the health and to beauty. . . . . . By such means, the women of the East render their skins softer than that of the tenderest babe in this climate." "I strongly recommend to every lady to make a bath as indispensable an article in her house as a looking-glass."

When the foul matters which ought to be eliminated by the skin and quickly removed from the body are allowed to remain undisturbed, the skin becomes clogged and inactive, soon loses its natural lustre and color, becoming dead, dark, and unattractive. When bathing is so much neglected, it is no marvel that paints, powders, lotions, and cosmetics of all sorts, are in such great demand. A daily bath, at the proper temperature, is the most agreeable and efficient of all cosmetics.

Bathing Protects against Colds.—It is an erroneous notion that bathing renders a person more liable to "take cold, by opening the pores." Colds are produced by disturbance of the circulation, not by opening or closure of the pores of the skin. Frequent bathing increases the activity of the circulation in the skin, so that a person is far less subject to chilliness and to taking cold. An individual who takes a daily cool bath has perfect immunity from colds, and is lit-

tle susceptible to changes of temperature. Colds are sometimes taken after bathing, but this results from some neglect of the proper precautions necessary to prevent such an occurrence, which are carefully stated elsewhere in this work.

Aristocratic Vermin.—Doubtless, not a few of those very refined and fastidious people who spend many hours in the application of all sorts of lotions and other compounds to the face and hands, for the purpose of beautifying those portions of the skin exposed to view—while neglecting as persistently those parts of the skin protected from observation—would be very much surprised to learn the true condition of the unwashed portions of their cutaneous covering. They instinctively shrink with disgust from the sight of a vermin-covered beggar, in whose cuticle burrows the *acarus scabiei* (itch-mite), while troops of larger insects are racing through his tangled locks and nibbling at his scaly scalp. It is quite possible that many a fair "unwashed" would faint with fright if apprized of the fact that her own precious covering is the home of whole herds of horrid-looking parasites which so nearly resemble the itch-mite as to be at least a very near relative, perhaps half-brother or cousin. The name of this inhabitant of skins unwashed is as formidable as the aspect of the creature, though it does not require a microscope to display its proportions, as does the latter; scientists call it, *demodex folliculorum*. See Plate VIII.

The *demodex* makes himself at home in the sebaceous follicles, where he dwells with his family. Here the female lays her eggs and rears her numerous family, undisturbed by the frictions of any flesh-brush, and only suffering a transient deluge at very long intervals, if such a casualty happens. In studying the structure of these little parasites, we have found several tenants occupying a single follicle, pursuing their domestic operations quite unmolested by any external disturbance.

The *demodex* has been transplanted from the human subject to the dog; and it is found that the new colony thrives very remarkably, and soon produces a disease apparently identical with that known as "mange."

We have not space to describe in detail these savage little brutes, with their eight legs, armed with sharp claws, bristling heads, sharp lancets for puncturing and burrowing into the skin, and their powerful suckers for drawing the blood of their victims. We care only to impress upon the mind of the reader the fact that neglect of bathing and friction of the skin is sure to encourage the presence of millions of these parasites, and that the only remedy is scrupulous cleanliness of the whole

person. Like their relatives, the itch-mite, they do not thrive under hydropathic treatment, and are very averse to soap and water. The best way to get rid of them is to drown them out. They do not produce the irritation which characterizes the presence of the itch insect, so that this evidence of their presence is wanting. But they are sure to be present in a torpid, unhealthy, unwashed skin, no matter how delicate or fastidious its possessor.

Bathing a Natural Instinct.—All nature attests the importance of the bath. The rain is a natural shower bath in which all vegetation participates, and gains refreshment. Its invigorating influence is seen in the brighter appearance, more erect bearing, and fresher colors of all plants after a gentle rain. The flowers manifest their gratitude by exhaling in greater abundance their fragrant odors. Dumb animals do not neglect their morning bath. Who has not seen the robin skimming along the surface of the lake or stream, dipping its wings in the cool waters, and laving its plumage with the crystal drops that its flapping pinions send glittering into the air? No school-boy who has ever seen the elephant drink will forget how the huge beast improved the opportunity to treat himself to a shower bath, and perhaps the spectators as well, for he is very generous in his use of water.

If man's instincts were not rendered obtuse by the perverted habits of civilization, he would value the bath as highly and employ it as freely as his more humble fellow-creatures, whose instinctive impulses have remained more true to nature, because they have not possessed that degree of intelligence which would make it possible for them to become so grossly perverted as have the members of the human race. Man goes astray from nature not because he is deficient in instinct, but because he stifles the promptings of his better nature for the purpose of gratifying his propensities.

Clothing.—The natural requirements for dress are the following:—

1. Modesty requires that the body should be clothed.

2. Protection against sudden changes of temperature is required for the maintenance of health.

The dusky savage who roams the tropical wilds of Central Africa finds no necessity for clothing. Modesty is to him unknown. The genial climate of his native forests insures him against vicissitudes of temperature, and so he lives as he was born, protected only by the swarthy cloak which nature gave him. Civilization creates the first requirement for clothing, and the varying temperatures of the temperate and frigid zones create the second.

Essential Qualifications of Clothing.—In order to properly meet the wants of the body in fulfilling the above requirements, clothing must possess the following qualifications:—

1. It must allow unrestrained action of every organ of the body.
2. It must secure equable temperature of all portions of the body.
3. Its weight must be as light as possible without sacrificing other necessary qualities.
4. It must be so adjusted to the body as to be carried with the slightest possible effort.

It will be admitted at once that clothing such as will meet the above requirements is not what is recommended by the fashion leaders of the day; but if ladies would forget fashion and make their garments in accordance with the principles of sound common sense, they would soon be delighted to find themselves emancipated from the numerous ills which afflict them in consequence of their present mode of dress, as has been already pointed out. It may be that circumstances will not always allow of the adoption of a dress which shall be wholly physiological in every respect, which is to be regretted. Custom has so long ruled that we are forced to yield a little to its mandates, though reluctantly. But it is quite possible for every woman to adopt a dress which shall be, in all essential particulars, free from serious defects, and that without sacrificing an iota of her native grace or modesty, or making a martyr of herself or her friends.

In the first place, the corset and all its substitutes and subterfuges, tight belts, and every other device for compressing the waist or any other part of the body can be at once discarded without the attention of any one being drawn to the fact unless it be by the more elastic and graceful step, the brighter color of the face, and the general improvement in health in all respects. Suppose the waist does expand a little—or a good deal, even—beyond the standard seventeen inches; is it any disgrace? No, indeed. A woman ought to be proud of a large waist. A large waist indicates large lungs, and large vital organs, which, in turn, represent the probabilities of long life. A small waist indicates precisely the opposite. Why should woman—the gentler sex—be compelled to wear a strait-jacket, like a madman or a criminal, while man is allowed to go untrammeled by any such impediment? A strong popular sentiment in favor of large waists would soon do away with the foolish emulation to look frail and slender. If required, a suitable garment may be made, to support the bust, which will fit the form neatly without com-

pressing any part. Able physicians declare that compression of this part of the body, and the wearing of an undue amount of clothing, thus producing a local increase of temperature, is the cause of many of the peculiar diseases of woman, acting through reflex influence upon internal organs.

The next important step should be to regulate the clothing properly. The whole body should be clad in soft flannel from neck to wrists and ankles nearly the year round. It is better to have the underclothing for the upper part of the body and that for the limbs combined in one garment. If arranged in two garments, they should only meet, and not overlap, as this gives too much additional heat over the abdominal organs. A woman's limbs require as many thicknesses as a man's; and a garment which fits the limb closely will afford four times the protection given by a loose skirt. Thick shoes or boots with high tops, and heavy woolen stockings which are drawn up outside the undergarments clothing the limbs, complete the provision for warmth. Leggins should be worn in cold weather.

All the undergarments should be suspended from the shoulders by means of waists or suspenders. Waists are doubtless the better for the purpose. If several garments are to be suspended from the same waist, the rows of buttons to which they are attached should be arranged one above another, to avoid bringing several bindings together.

The two *most important* particulars having been secured—freedom from compression and uniform temperature—the outside dress may receive attention. It should be as simple as possible, and consistent with the mental comfort of the wearer. Gaudy colors and conspicuous ornaments betray poor taste and a vain, shallow mind. Many flounces, folds, and heavy overskirts are objectionable on account of their weight, to say nothing of the useless expenditure of time and money which they occasion.

The proper length of the skirt is a question of interest in this connection. How long shall it be? If physiology alone were asked the question, the answer would be that women do not need long skirts more than men, and that they are really an impediment to locomotion, and often very inconvenient. Long-established custom says that women *must* wear skirts. Fashion says she must wear *long* skirts. Custom and fashion have prevailed so long that they have created an artificial modesty which seems to demand that woman's dress shall differ from man's by the addition of a skirt, at least, even if they are

alike in all other particulars. This being the case, the best we can do is to modify the skirt so that it will be as free from objections as possible. The great evils of long skirts are, unnecessary weight, the accumulation of moisture which is transferred to the feet and ankles, and sundry inconveniences to the wearer in passing over rough places, up and down stairs, etc.

The obvious remedy for these defects is to curtail the length of the dress. The train must be discarded at once as too absurd and uncleanly, with its filthy load of gleanings from the gutter, to be tolerated. Any further improvement, to be of practical utility, must shorten the skirt to the top of the ankle; and a radical dress-reformer will want to make it a few inches shorter.

A very serious mistake is made by those who adopt the reform in the length of the dress, even to the fullest extent, but make no reform in other respects. Such overlook the chief defects which need reformation, paying their whole attention to a point which, considered from a physiological standpoint, is of minor importance, although well deserving of all the attention it receives.

False Hair and Hair Dyes.—The ungainly masses of unnecessary material which fashion has heaped upon the heads of those who bow to her authority, are a frightful cause of diseases of the scalp and brain. The immense loads of hair, jute, or other material, which are attached to the head, cause a great increase of the temperature of the brain and scalp. The blood-vessels become congested, both externally and internally. The result of this constant surplus of blood is disease of the scalp and of the brain itself. Headache is an almost constant symptom of the injury which is being wrought by this improper treatment of the head.

In consequence of the disease of the scalp, the hair soon becomes diseased, loses its brilliancy and color, becomes dry and harsh, and in many cases is lost altogether, complete and incurable baldness ensuing.

The congestion of the brain which at first occasions only headache, when continued produces structural disease of that organ. The blood-vessels become weakened, and sometimes ruptured, when the patient either dies of apoplexy or lingers a miserable paralytic.

When the head is encumbered with an unnatural mass of hair, and the brain is clogged by the excessive amount of blood and supernatural heat which result, the mind cannot act freely and naturally; hard study, deep thought, and continued mental exercise are impossible. This is the

reason why fashionable young ladies find study so hard for them, and apparently injurious. The incubus of such a prodigious weight as many a fashionable lady carries upon her cranium would be quite sufficient to eclipse the mental powers of the most brilliant genius. No wonder that woman has sometimes failed in mental competition with her brothers in the schools. The wonder is that she lives and possesses even a modicum of mental vigor. Under equally favorable circumstances, woman should be man's peer in mental power and development; but if she wishes to secure and maintain the equality of the sexes, which so many earnest women are just now demanding, she must throw away her chignons and waterfalls, shake off her "rats and mice," and don a simpler, healthier head-gear.

The real hair that is sold to those whose tresses are considered too scanty is chiefly obtained from the bodies of dead persons, whose graves are plundered for the purpose by wretches who earn their living by this means. Vermin of various kinds often adhere to the hair, and infest the heads of those who wear it. Various imitations of hair also become the means of conveying loathsome parasites to the scalps of those who wear them.

The use of hair dyes is a practice which the chemist and experience have both shown to be eminently dangerous. All hair dyes are poisonous. No matter how strong the assertions of their harmlessness, they are utterly false. So-called vegetable hair dyes, hair invigorators, tonics, etc., are contemptible swindles. They contain mineral poisons. The greater portion of them contain lead. The effect of their use is not only to destroy the hair, and induce disease of the scalp, but to produce paralysis. Many cases of chronic headache have been occasioned by the use of these poisonous mixtures; and in a number of cases, insanity has been the result.

The use of these vile compounds, which are so widely sold and used, is usually as absurdly foolish as harmful.

The Kidneys.—Figs. 131 and 132. These organs are located in the back part of the abdominal cavity, between the lower ribs and the upper border of the hip bone. In shape they resemble a kidney-bean, and each weighs four to six ounces. The greater portion of the kidney is made up of minute tubes, which terminate in the outer part of the organ in extremely minute round sacs, each of which contains a delicate, coiled capillary blood-vessel. It is by these bodies that the elements of the urine are separated from the blood. All the tubes

lead toward the center of the organ, where they empty into a cavity called the *pelvis* of the kidney, which narrows down into a small canal, the *ureter*, by which the urine is conveyed to the *bladder*, a pouch-like reservoir located in the lower part of the abdomen, from which the urine is discharged through another small canal, the *urethra*.

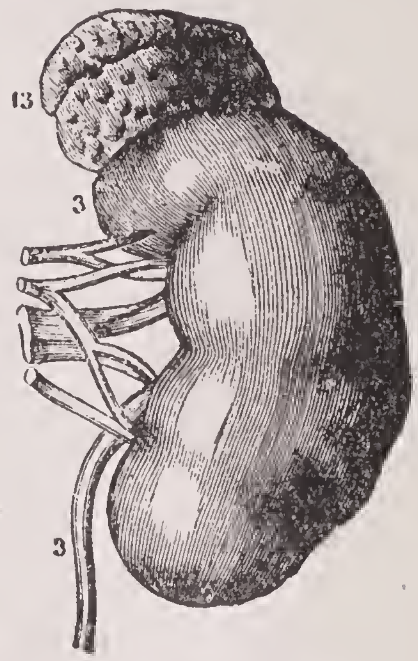


Fig. 131. The Kidney, showing the arteries and veins of the organ; 13. the Supra-renal Capsule; and 3. the Ureter.

The urine is chiefly composed of water, which carries in solution a large number of excrementitious principles, the chief of which is urea, one of the most abundant and most poisonous of all the waste elements of the body. When the liver is inactive, the urine usually contains some biliary elements. Sugar is also found in the urine soon after a meal in which an excess has been taken. The condition of the urine is an important means of ascertaining the state of the system, and hence we shall speak elsewhere of the various points to be learned by its chemical and microscopical examination.

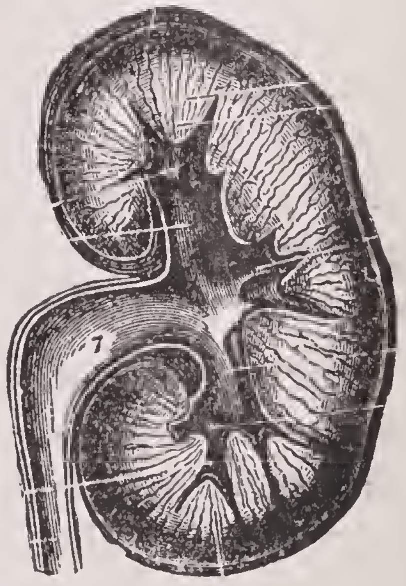


Fig. 132. Showing the internal structure of the Kidneys.

The Liver.—This is the largest gland in the body, weighing between four and five pounds. It is a little larger, proportionately, in women than in men. The liver is made up of minute, roundish lobules, about $\frac{1}{25}$ of an inch in diameter, each of which is furnished with branches from the hepatic artery and also from the portal vein. The liver thus contains a double capillary net-work. In addition, there is a system of minute ducts or canals running through its whole substance, by means of which the bile which is separated from the portal vein is drained off into a pouch upon its under surface, the gall bladder, or into the small intestine.

The Bile.—This is a greenish, bitter, alkaline fluid, somewhat viscid in character. The amount produced each day is about two and one-half pounds. It is produced much more rapidly during digestion than at other times.

As already observed, the bile is both a secretion and an excretion. As a secretion, it aids digestion. As an excretion, it removes from the body a poisonous substance called *cholesterine*, a waste product of the nervous system. This, when concentrated, is found to be a resinous substance. It forms the chief part of many gall-stones.

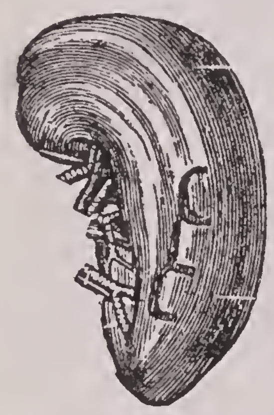


Fig. 133. Spleen.

The functions of the liver are somewhat complicated. In addition to its secreting and excretory functions, it is thought to be a sugar-forming organ, and to be capable of completing the digestion of some elements of the food. It is thought by some, also, that it destroys and removes from the system worn-out red blood corpuscles.

The Spleen.—Among other glands should also be mentioned the spleen (Fig. 133), a gland found in the left side of the abdominal cavity next to the left end of the stomach, to which it is attached. Its weight is about seven ounces. It belongs to a class of structures known as blood glands or ductless glands, because it has no duct. However, it receives a very large supply of blood, and is supposed to have something to do with the production or destruction of blood corpuscles. It may be removed from the body, in animals, without producing death. The effect of its removal in cats is to cause them to become very fat. It is also observed that they become very irritable after its removal. It is said that the farmers in some parts of England make a practice of removing the spleen in young calves in order to cause them to fatten faster.

Other Blood Glands.—Under this head are also included the supra-renal capsules, which are attached to the upper part of the liver; the thyroid gland, situated at the upper part and on either side of the trachea; the thymus gland, found only in early life, at the lower part of the trachea; the pituitary body and the pineal gland, found in the central part of the brain. Of these glands little else is known than their location and structure.

Animal Heat.—Warm-blooded animals possess the power to regulate their own temperature independent of external temperatures, at least within certain limits. What are called cold-blooded animals do not possess this power, their temperature depending on that of the medium with which they are surrounded. The source of animal heat is the various vital changes constantly taking place in the body.

This is shown by the fact that the amount of heat produced is exactly proportionate to the intensity of the vital changes. In health the temperature of the body is about 98½° F. When the system is under the influence of fever or an extensive inflammation of any sort,—which process greatly accelerates vital changes,—the temperature rises several degrees above the normal standard, sometimes as high as 110° F., though a temperature above 107° is considered to be almost certainly fatal if long continued. This same principle is observed in lower animals and even in flowering plants. The latter absorb oxygen most rapidly when flowering; and in many instances it has been shown by careful experiment that the process of flowering in plants is accompanied with a marked production of heat. Birds absorb large quantities of oxygen, and have very active vital processes. In them the temperature of the body is several degrees higher than in man and quadrupeds. In fish and reptiles, on the other hand, in which the vital processes are much slower, the temperature is much lower, being, in fact, usually about that of the surrounding air or water in which they live, their heat production being actually too small to enable them to maintain an independent temperature. A French physiologist experimented upon a marmot a few years ago, and found that when the animal was asleep, its temperature was only about 40° F., while it was 89° F. when awake. In all hibernating animals there is a marked decrease in the temperature while the animal is in a state of hibernation.

There is good reason for believing that the friction of the blood in the blood-vessels is an important source of heat. Carefully conducted experiments show that the force exerted by the heart each twenty-four hours, which is all used up or transformed in the body, is equivalent to more than 1,000 degrees of heat, or sufficient to raise 100 lbs. of water 10° F. in temperature. The fact that heat is produced by conversion of the force expended in the circulation, is further shown by a series of experiments made by the eminent French physiologist, Bernard, for the purpose of ascertaining the temperature of the blood in various parts of the body. He found that the blood of the portal vein and that of the hepatic vein is warmer than that of any other part of the body, that in the hepatic vein showing the highest temperature of all, which is undoubtedly attributable to the fact that the blood of this vein has passed through two sets of capillaries, so that its circulatory force has been almost wholly converted into heat.

REPRODUCTION.

Believing that ignorance on this subject lies at the root of some of the most serious diseases and the most degrading vices to which human beings are subject, we have not hesitated to introduce it here in order to do our part in enlightening the world with reference to the dangers from a source which, too often unsuspected, pours forth contamination and degradation, blighting the prospects of the most promising, and sparing none who place themselves knowingly or unwittingly within its reach. The greater portion of this chapter is in substance quoted from our work upon the subject entitled, "Plain Facts for Old and Young."

Reproduction is a function common to all animals and to all plants. Every organized being has the power to reproduce itself, or to produce, or aid in producing, other individuals like itself. It is by means of this function that plants and animals increase or multiply.

When we consider the great diversity of characters illustrated in animal and vegetable life, and the infinite variety of conditions and circumstances under which organized creatures exist, it is not surprising that modes of reproduction should also present great diversity both in general character and in detail.

Simplest Form of Generation.—Deep down beneath the waters of the ocean, covering its bottom in certain localities, is found a curious slime, which, under the microscope, is seen to be composed of minute rounded masses of gelatinous matter, or protoplasm. By watching these little bodies intently for a few minutes, the observer will discover that each is a living creature capable of moving, growing, and assuming a variety of shapes. Continued observation will reveal the fact that these little creatures multiply; and a more careful scrutiny will enable him to see *how* they increase. Each divides into two equal parts so nearly alike that they cannot be distinguished from each other. In this case the process of generation is simply the production of two similar individuals from one.

A small quantity of slime taken from the surface of a stone near the bottom of an old well or at the seaside, when placed under the microscope, will sometimes be found to contain large numbers of small, round, living bodies. Careful watching will show that they also mul-

tiply by division ; but before the division occurs, two cells unite to form one by a process called *conjugation.* Then, by the division of this cell, instead of only two cells, a large number of small cells are formed, each of which may be considered as a bud formed upon the body of the parent cell and then separated from it to become by growth an individual like its parent, and, like it, to produce its kind. In this case, we have new individuals formed by the union of two individuals which are to all appearance entirely similar in every particular.

Sex.—Rising higher in the scale of being, we find that, with rare exceptions, reproduction is the result of the union of two dissimilar elements. These elements do not, in higher organisms, as in lower forms of life, constitute the individuals, but are produced by them ; and being unlike, they are produced by special organs, each adapted to the formation of one kind of elements. The two classes of organs usually exist in separate individuals, thus giving rise to distinctions of *sex;* an individual possessing organs which form one kind of elements being called a male, and one possessing organs for the formation of the other kind of elements, a female. The sexual differences between individuals of the same species are not, however, confined to the sexual organs. In most classes of plants and animals, other sexual differences are very great. In some of the lower orders of animals, and in many species of plants, the male and female individuals are so much unlike that for a long time after they were well known, no sexual relation was discovered.

Hermaphrodism.—An individual possessing both male and female organs of reproduction is called an *hermaphrodite.* Such a combination is very rare among higher animals; but it is by no means uncommon among plants and the lower forms of animal life. The snail, the oyster, the earth-worm, and the common tape-worm, are examples of true hermaphrodites. So-called human hermaphrodites are usually individuals in whom the sexual organs are abnormally developed so that they resemble those of the opposite sex, though they really have but one sex, which can usually be determined with certainty. Only a very few cases have been observed in which both male and female organs were present.

There is now living in Germany an individual who bears the name of a woman; but learned physicians have decided that the person is as much man as woman, having the organs of both sexes. What is

still more curious, this person has the feelings of both sexes, having loved at first a man, and afterward a woman. There have been observed, also, a very few instances of individuals in whom the sexual organs of neither sex were present. It thus appears that a person may be of both sexes or of no sex at all.

Sex in Plants.—To one unacquainted with the mysteries of plant life and growth, the idea of attaching sexuality to plants seems very extraordinary; but the botanist recognizes the fact that the distinctions of sex are as clearly maintained in the vegetable as in the animal kingdom. The sexual organs of the higher orders of plants are flowers. That part of the flower which produces seeds answers to the female; another part, which is incapable of forming seeds, answers to the male. The fertile and sterile flowers are sometimes produced on separate plants. Very frequently, they are produced upon separate parts of the same plant, as in the oak, walnut, and many other forest trees, and Indian corn. In the latter plant, so familiar to every one, the "tassel" contains the male flowers, and the part known as the "silk," with the portion to which it is attached—which becomes the ear—the female or fertile flowers. In a large number of species, the male and female organs are combined in a single flower, making a true hermaphrodite.

Sex in Animals.—As previously remarked, individuals of opposite sex usually differ much more than in the character of their sexual organs only. Among higher animals, the male is usually larger, stronger, and of coarser structure than the female. The same contrast is observed in their mental characters. With lower animals, especially insects, the opposite is often observed. The female spider is many times larger than the male. The male ant is small in size when compared with the female. Nevertheless, in all classes of animals the difference in the structure and the functions of the sexual organs is the chief distinguishing character. These differences are not so great, however, as they might at first appear. The male and female organs of reproduction in man and other animals, which seem so dissimilar, when studied in the light shed upon this subject by the science of embryology, are found to be wonderfully alike in structure, differing far more in appearance than in reality, and being little more than modifications of one general plan. Every organ to be found in the one sex has an analogue in the other which is complete in every particular, corresponding in function, in structure, and usually in position.

Other Sexual Differences.—In this country there is between five and six inches difference in height and about twenty pounds difference in weight between the average man and the average woman, the average man being about five feet, eight inches in height, and weighing one hundred and forty-five pounds; while the average woman is five feet, two or two and one-half inches in height, and weighs one hundred and twenty-five pounds. The relation of the sexes in height and weight varies in degree in different countries, but is never changed. The average height and weight of American men and women is above that of the average human being.

Men and Women Differ in Form.—The differences in form are so marked that it is possible for the skilled anatomist to determine the sex of a human being who has been dead for ages, by an examination of the skeleton alone. In man, the shoulders are broad, the hips narrow, and the limbs nearly straight with the body. In woman, the shoulders are narrow and usually rounded, and set farther back, the collar-bone being longer and less curved, giving the chest greater prominence; while the hips are broad.

The consequence of these differences is that woman is generally less graceful and naturally less skillful in the use of the extremities than man, and hence less fitted for athletic sports and feats requiring great dexterity. A girl throws a stone awkwardly, less from want of practice than from a natural peculiarity of physical structure. A woman walks less gracefully than a man, owing to the greater relative breadth of her hips, requiring a motion of the body together with that of the limbs. In consequence of this peculiarity, a woman is less fitted for walking long distances.

The Male and the Female Brain.—But there are other important physical differences to which we must call attention. Man possesses a larger brain than woman, but she makes up the deficiency in size by superior fineness in quality. The female brain differs from the masculine organ of mentality in other particulars so marked that one who has given the subject attention can determine with perfect ease the probable sex of the owner of almost any skull which might be presented to him. This difference in the conformation of the skull is undoubtedly due to a difference in mental character, which, in turn, depends upon a difference in cerebral development.

Vital Organs of Man and Woman.—The anatomist also observes an interesting difference in the size of the various vital organs. For

example, while a woman has a heart proportionally smaller than the same organ in man, she has a larger liver. Thus, while less well fitted for severe physical exertion by less circulatory power, she has superior excretory powers.

This peculiarity of structure is perfectly harmonious with the fact which experience has established so often as to make the matter no longer a question, that woman is less fitted for severe muscular exertion than man, but possesses in a superior degree the quality known as endurance. With a less robust frame, a more delicately organized constitution, she will endure for months what would kill a robust man in as many weeks. More perfect elimination of the wastes of the body secures a higher grade of vitality. On no other hypothesis could we account for the marvelous endurance of the feminine part of the civilized portion of the human race, ground down under the heel of fashion for ages, "stayed," "corseted," "laced," and thereby distorted and deformed in a manner that would be fatal to almost any member of the masculine sex.

The Reproductive Elements.—As has been previously observed, in all except the very lowest forms of life, two elements are necessary to the production of a new individual, or a reproduction of the species,—a male element and a female element. The special organs by means of which these elements are produced, brought together, and developed into the new individual in a more or less perfect state, are termed *sexual organs*, as we have already seen. As an introduction to the specific study of the sexual organs in the human species, let us briefly consider the—

Sexual Organs of Plants.—As already remarked, flowers are the sexual organs of plants. Nothing is more interesting in the natural world than the wonderful beauty, diversity, and perfect adaptability to various conditions and functions, which we see in the sexual parts of plants. An exceedingly interesting line of study, which has occupied the attention of many naturalists, is the wonderful perfection displayed in the adaptability of the male and female parts of plants to each other. Without burdening the reader with unnecessary technicalities of detail, we will briefly notice the principal parts of vegetable sexual organs as illustrated in flowers.

Complete flowers are made up of four parts, two of which, the *stamen* and *pistil*, are essential, while the other two, the calyx and corolla, are accessory.

The *calyx* is that part which surrounds the flower at its outer and

lower part. It varies greatly in form and color, but is most frequently of a green or greenish color.

Just within the calyx is the *corolla,* which usually forms the most attractive, showy, and beautiful part of the flower. The beautifully colored petals of the rose, geranium, dahlia, and similar flowers, form their corollas. In Fig. 134 is given a diagramatic view of the various parts of a perfect flower.

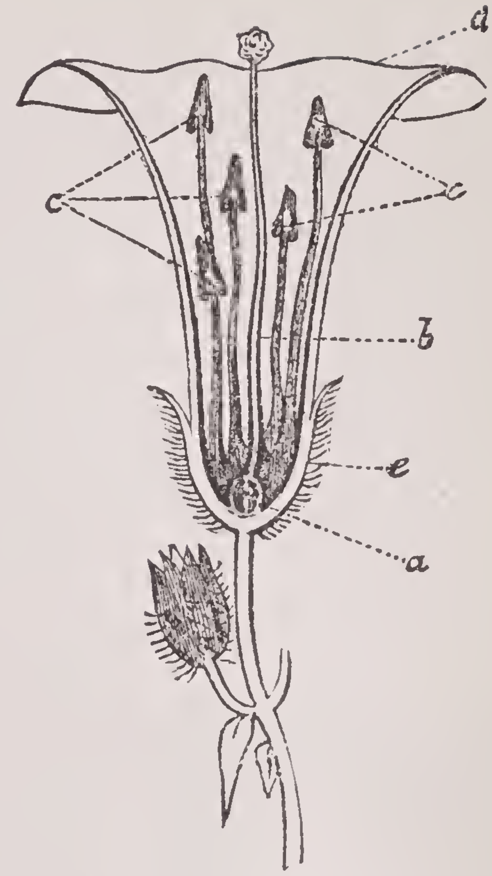


Fig. 134. *a.* Ovary; *b.* Pistil; *c c.* Stamens and Anthers; *d.* Corolla; *e.* Calyx.

Sexual Organs of Animals.—The male reproductive element is called a *spermatozoön* or *zoösperm.* The female element is called an *ovum,* literally, an egg.

A spermatozoön somewhat resembles a tadpole in appearance, having, however, a much longer tail in proportion to the size of the body, as will be seen by reference to Fig. 135.

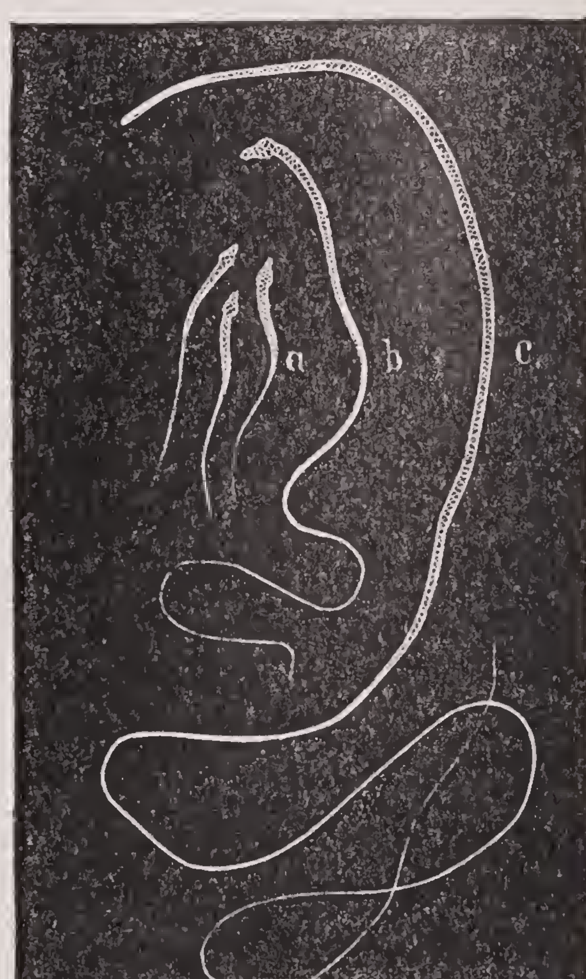


Fig. 135. *a.* Human Spermatozoa; *b.* Spermatozoa of the rat; *c.* Spermatozoa of Menobranchus. (Dalton.)

Human spermatozoa are about $\frac{1}{600}$ of an inch in length. Those of reptiles are very much larger. One of the remarkable features of these minute elements is their peculiar movements. While alive, the filamentous tail is in constant action in a manner strongly resembling the movements of the caudal appendage of a tadpole. This wonderful property led the earlier observers to believe that they were true animalcula. But they are not to be regarded as such, though one can scarcely make himself believe otherwise while watching their lively evolutions, and apparent volitionary movements from one point to another.

In man the formation of spermatozoa continues with greater or less rapidity from puberty to old age, though at the two extremes of existence they are imperfectly developed. When not discharged from the body, they are said to be absorbed. Some physiologists claim that they are composed of a substance identical with nerve tissue, and that by absorption they play a very important part in the development and maintenance of the nervous system.

It is asserted by good authorities that the reproductive element in man is not so well developed as to be really fit for the reproduction of the species before the age of twenty-four or twenty-five. After the age of forty-five or fifty, the reproductive elements deteriorate in quality, and become again unfitted for vigorous procreation.

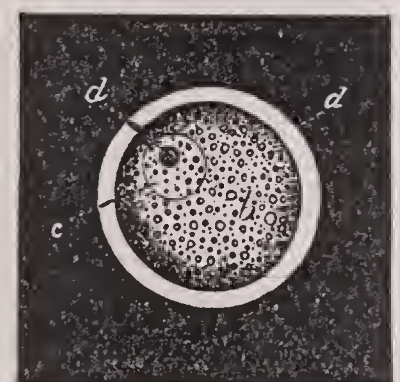


Fig. 136. Human Ovum, magnified one hundred and thirty diameters. (Dalton.)

The Ovum.—Fig. 136. The female element of generation, the ovum, is produced by an organ called the *ovary*, of which there are two in each individual. The human ovum varies in size from $\frac{1}{240}$ to $\frac{1}{120}$ of an inch in diameter, and consists of a single cell. Ova are not formed in such large numbers as zoösperms. As a general rule, in the human female, a single ovum is developed and discharged once in about four weeks, during the period of sexual activity.

Fecundation.—It is often asked, and the question has elicited some discussion, Which is the principal reproductive element; the zoösperm, or the ovum? The ancients supposed the male element to be the essential element, being simply nourished and developed by the female; but modern research in biological science does not sustain this view. Probably neither one enjoys especial preëminence; for neither can undergo complete development without the other. In very rare cases, the ovum has been observed to undergo a certain amount of development of itself; but a perfect individual can be produced only by the union of the two kinds of elements, which process is known as *fecundation*. The instant this union occurs, the life of a new individual begins. All the changes which result between that moment and the birth of the individual are those of development only. Indeed, the same existence continues from the instant of the union of the two elements, not only until birth, but through growth, the attainment of maturity, the decline of life, and even until death.

It is interesting to observe the different methods by which fecundation is effected, both in plants and animals, for this is a process common to both.

Fecundation in Flowers.—The great naturalist, Linnæus, was the first to explain the reproductive process in plants. He tells us that "the flower forms the theater of their amours; the calyx is to be considered as the nuptial bed; the corolla constitutes the curtains; the anthers are the testes; the pollen, the fecundating fluid; the stigma of the pistil, the external genital aperture; the style, the vagina, or the conductor of the prolific seed; the ovary of the plant, the womb; the reciprocal action of the stamens on the pistil, the accessory process of fecundation."

Modes of Fecundation in Animals.—The modes by which fecundation is effected in animals are still more various and wonderful than in plants. In some of the lower animals, as in most fish and reptiles, both elements are discharged from the bodies of the parents before coming in contact, there being no contact of the two individuals. In this class of animals the process is almost wholly analogous to fecundation in those plants in which the male and female flowers are on different plants or different parts of the same plant. In the female fish, a large number of ova are developed at a certain season of the year known as the spawning season. Sometimes the number reaches many thousands. At the same time, the testicles of the male fish, which are contained within the abdominal cavity, become distended with developed zoösperms. When the female seeks a place to deposit her eggs, the male closely follows; and as she drops them upon the gravelly bottom, he discharges upon them the zoösperms by which they are fecundated. The process is analogous to that observed in some species of frogs. When the female is about to deposit her eggs, the male mounts upon her back and rides about until the eggs are all deposited, discharging upon them the fertilizing spermatozoa as they are laid by the female.

Development.—After the union of the two elements, known as fecundation or *conception*, if the conditions are favorable, development occurs, and the little germ is in due process of time developed into an individual which is an exact counterpart of its parents. During this developmental process, the embryonic being is variously treated by different classes of animals.

Unprotected Development.—Most fishes and reptiles discharge their ova before fecundation, or soon after, and pay no further attention to them. The fish deposits its eggs in a little hollow scooped out in the gravelly bed of a stream, or sows them broadcast upon the waters. The turtle buries its eggs in the sand, and leaves them to be hatched by the sun. The ostrich disposes of her eggs in the same way. Many other species of animals pay no regard to the protection of the germs which are destined, if placed under favorable conditions, to become individuals like themselves.

Development in the Higher Animals and Man.—Higher animals are less prolific, and their development is a more complicated process; hence, their young need greater protection, and, for this reason, the ova, instead of being discharged from the body of the female after fecundation, are retained.* As we have seen that a suitable receptacle is sometimes provided outside of the body, so now a receptacle is needed, and is provided in the interior of the body of the female. This receptacle is called—

The Uterus.—This is a hollow, pear-shaped organ, located in the median line, just behind the bladder, between it and the rectum. It is supported in place by various ligaments and by the juxtaposition of other organs. Its larger end is directed upward, and communicates upon each side with a very narrow tube which is prolonged outward on either side until it nearly touches the ovary of the same side. When an ovum is matured, it escapes from the ovary into the narrow tube referred to, called the *Fallopian tube,* and passes down into the cavity of the uterus. If fecundation does not occur, it is expelled or absorbed after six to twelve or fourteen days.

Uterine Gestation.—This is the term applied to the process last referred to. We shall not attempt to describe in detail this most wonderful and intricate of all living processes; but will sketch only the chief points, leaving the reader who would obtain a more complete knowledge

* Curious examples of internal development sometimes occur in animals which usually deposit eggs. Snakes have been known to produce both eggs and living young at the same time. At the annual meeting of the American Society for the Advancement of Science, at Detroit, Mich., in August, 1875, we had the pleasure of examining a specimen, exhibited by Prof. Wilder, of a chick which had undergone a considerable degree of development within the ovary of the hen. It had a head, a rudimentary brain, and internal viscera, but no feathers nor limbs. It was, in fact, an egg hatched before it had been laid. This anomaly excited much interest at that time and since among biologists.

of the subject to consult any one of the numerous physiological and obstetrical works which deal with it in a very exhaustive manner.

As soon as the ovum is impregnated by the male element, it begins a process of symmetrical division. The first division produces two cells out of the single one which first existed. By the next division, four segments are produced; then eight, sixteen, etc. Fig. 137. While this process is going on, the ovum becomes adherent to the internal wall of the uterus, and is soon enveloped by its mucous membrane, which grows up about and incloses it.

The Primitive Trace.—When the process of segmentation has advanced to a certain point, the cells are aggregated together in a compact layer at the surface. Soon a straight line appears upon this layer, which is called the *primitive trace.* Fig. 138. This delicate line becomes the basis for the spinal column; and upon and about it the whole individual is developed by an intricate process of folding, dividing, and reduplica-

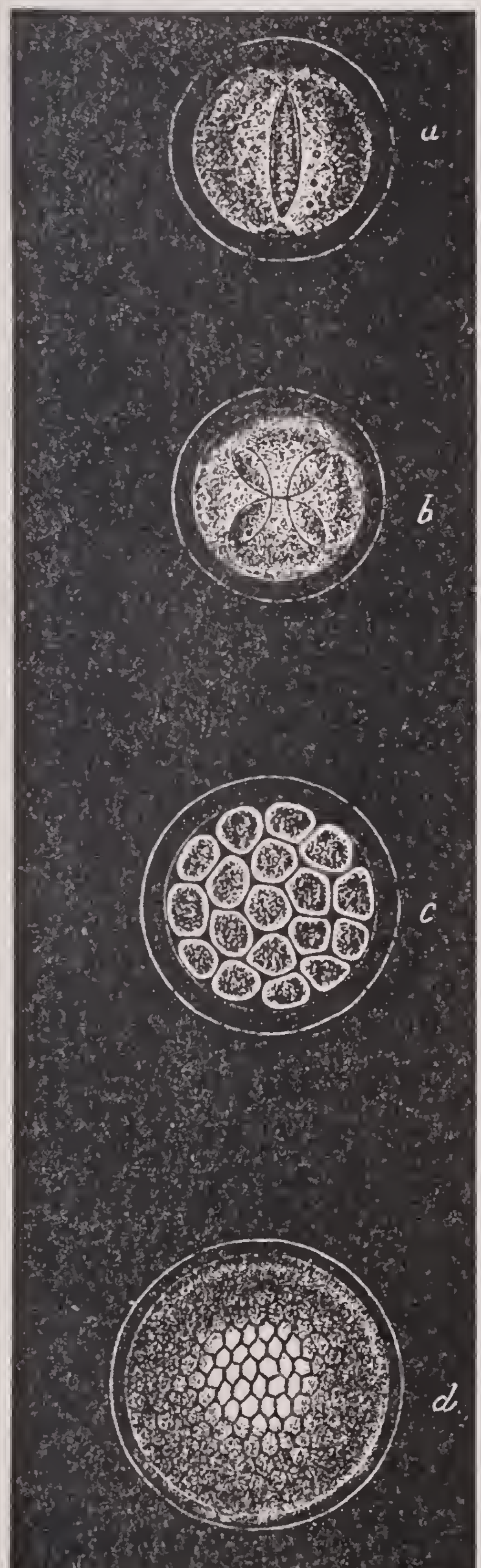


Fig. 137. Diagram illustrating the segmentation of the Ovum.

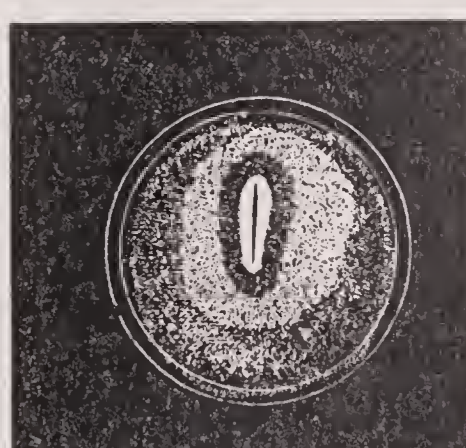


Fig. 138. The Human Ovum after fecundation, showing primitive trace.

tion of the layer of cells. One end of the line becomes the head, and the other becomes the tail. Even man has a caudal appendage at an early stage of his existence. After a further lapse of time, little excrescences, buds, or "pads," appear in the proper positions to represent the arms and legs. After further development the ends split up into fin-

gers and toes, and by the continued development of the parts, perfect arms and legs are formed.

Curious Relation to Lower Animals.—It is a very remarkable fact that in the lower animals we have numerous examples in which the permanent condition of the individual is the same as some one of the stages through which man passes in the process of development. An eminent author makes the following interesting statements:—

"The webbed feet of the seal and ornithorhynchus typify the period when the hands and feet of the human embryo are as yet only partly subdivided into fingers and toes. Indeed, it is not uncommon for the 'web' to persist to some extent between the toes of adults; and occasionally children are born with two or more fingers or toes united to their tips.

"With the seal and the walrus, the limbs are protruded but little beyond the wrist and ankle. With the ordinary quadrupeds, the knee and elbow are visible. The cats, the lemurs, and the monkeys form a series in which the limbs are successively freed from the trunk, and in the highest apes they are capable of nearly the same movements as the human arm and leg, which, in their development, passed through all these stages."

Simplicity of Early Structures.—The first structures formed are exceedingly simple in form. It is only by slow degrees that the great complexity which characterizes many organs is finally attained. For example, the heart is at first only a straight tube. By enlargement and the formation of longitudinal and transverse partitions, the fully developed organ is finally produced. The stomach and intestines are also at first but a simple straight tube. The stomach and large intestine are formed by dilatation; and by a growth of the tube in length while the ends are confined, the small intestines are formed. The other internal organs are successively developed by similar processes.

The Stages of Growth.—At first insignificant in size,—a simple cell,—the embryonic human being steadily increases in size, gradually approximating more and more closely to the human form, until, at the end of about nine calendar months, or ten lunar months, the new individual is prepared to enter the world and begin a more independent course of life. The following condensation of a summary quoted by Dr. Austin Flint, Jr., will give an idea of the size of the developing being at different periods, and the rate of progress:—

At the end of the third week, the embryon is a little less than one-fourth of an inch in length.

At the end of the seventh week, it is three-fourths of an inch long. The liver, lungs, and other internal organs are partially formed.

At the eighth week, it is about one inch in length. It begins to look some like a human being, but it is impossible to determine the sex.

At the third month, the embryon has attained the length of two to two and one-half inches. Its weight is about one ounce.

At the end of the fourth month, the embryon is called a fetus. It is from four to five inches long, and weighs five ounces.

At the fifth month, the fetus is nearly a foot long, and weighs about half a pound.

At the sixth month, the average length of the fetus is about thirteen inches, and its weight one and a half to two pounds. If born, life continues but a few minutes.

At the seventh month, the fetus is from fourteen to fifteen inches long, and weighs two to three pounds. It is now viable (may live if born).

At the eighth month, the length of the fetus is from fifteen to sixteen inches, and its weight from three to four pounds.

At the ninth month, the fetus is about seventeen inches long, and weighs from five to six pounds.

At birth, the infant weighs a little more than seven pounds, the usual range being from four to ten pounds, though these limits are sometimes exceeded.

Duration of Gestation.—The length of time required for the development of a human being is usually reckoned as about forty weeks. A more precise statement places it at about two hundred and seventy-eight days. This limit is often varied from. Cases have occurred in which a much longer time has been required, and numberless cases have occurred in which human beings have been born several weeks before the expiration of the usual time, as stated. There is some uncertainty respecting the exact length of the period of gestation, which grows out of the difficulty of determining, in many cases, the exact time when conception takes place.

Uterine Life.—The uterine life of the new individual begins with the impregnation of the ovum, which occurs the instant it is

brought in contact with the zoösperms of the male. While in the uterus, the young life is supported wholly by the mother. She is obliged to provide not only for her own sustenance, but for the maintenance of her child. And she must not only eat for it, but breathe for it as well, since it requires a constant and adequate supply of oxygen before birth as much as afterward.

How the Unborn Infant Breathes.—Oxygen and nutriment are both supplied to it through the medium of an organ called the *placenta,* which is a spongy growth composed almost entirely of blood-vessels, and is developed upon the inner wall of the uterus, at the point at which the ovum attaches itself after fecundation. The growing fetus is connected with this vascular organ by means of a sort of cable, called the *umbilical cord.* The cord is almost entirely composed of blood-vessels, which convey the blood of the fetus to the placenta and return it again. The fetal blood does not mix with that of the mother, but receives oxygen and nourishment from it by absorption through the thin walls which alone separate it from the mother's blood.

The umbilical cord contains no nerves, as there is no nervous connection between the mother and the child. The only way in which the child can be influenced by the mother is through the medium of the blood, to changes in which it is very susceptible, as we shall see more clearly hereafter.

The cord is attached to the body of the child at the point called the *navel,* being cut off at birth by the *accoucheur.* With the placenta, it is expelled soon after the birth of the child, and constitutes the shapeless mass familiarly known as the *after-birth,* by the retention of which the most serious trouble is occasionally caused.

Parturition.—At the end of the period of development, the young being is forcibly expelled from the laboratory of nature in which it has been formed. In other words, it is born; and this process is termed *parturition.* Though, at first thought, such an act would seem an utter impossibility, yet it is a very admirable illustration of nature's adaptation of means to ends. During the months of gestation, while the uterus has been enlarging to accommodate its daily increasing contents, the generative passages have also been increasing in size and becoming soft and distensible, so that a seeming impossibility is in due time accomplished without physical damage,

though possibly not without intense suffering. However, it is a most gratifying fact that modern medical science may do much to mitigate the pains of childbirth. It is possible, by a proper course of preparation for the expected event, to greatly lessen the suffering usually undergone; and some ladies assert that they have thus avoided real pain altogether. Although the curse pronounced upon the feminine part of the race, in consequence of the sin of Eve, implies suffering in the parturient act, yet there is no doubt that the greater share of the daughters of Eve are, through the perverting and degenerating influences of wrong habits and especially of modern civilization, compelled to suffer many times more than their maternal ancestor. We have sufficient evidence of this in the fact that among barbarian women, who are generally less perverted physically than civilized women, childbirth is regarded with very little apprehension, since it occasions little pain or inconvenience. The same is true of many women among the lower laboring classes. In short, while it is true that more or less suffering must always accompany parturition, yet the excessive pain usually attendant upon the process is the result of causes which can in many cases be removed by proper management beforehand and at the time of confinement.

After being relieved of its contents, the uterus and other organs rapidly return to nearly their original size.

Changes in the Child at Birth.—In the system of the child a wonderful change occurs at the moment of its expulsion into the outer world. For the first time, its lungs are filled with air. For the first time, they receive the full tide of blood. The whole course of the circulation is changed, and an entirely new process begins. It is surprising in how short a space of time changes so marvelous can be wrought.

Nursing.—The process of development is not fully complete at birth. The young life is not yet prepared to support itself; hence, still further provision is necessary for it. It requires prepared food suited to its condition. This is provided by the *mammæ*, or breasts, of the female, which are glands for secreting milk. The fully developed gland is peculiar to the female; but a few instances have been known in which it has been sufficiently developed to become functionally active in men, as well as in young girls, though it is usually inactive even in women until near the close of gestation. It is a curious fact that the breasts of a new-born child occasionally contain milk.

The first product of the mammæ is not the proper milk secretion,

but is a yellowish fluid called *colostrum*. The true milk secretion begins two or three days after delivery.

The lacteal secretion is influenced in a very remarkable manner by the mental conditions of the mother. By sudden emotions of grief or anger, it has been known to undergo such changes as to produce in the child a fit of indigestion, vomiting, diarrhea, and even convulsions and death. Any medicine taken by the mother finds its way into the milk, and often affects the delicate system of the infant more than herself. This fact should be a warning to those nursing mothers who use stimulants. Cases are not uncommon in which delicate infants are kept in a state of intoxication for weeks by the use of alcoholic drinks by the mother. The popular notion that lager-beer, ale, wine, or alcohol in any other form, is in any degree necessary or beneficial to a nursing woman is a great error which cannot be too often noticed and condemned. Not only is the mother injured, instead of being benefited, by such a practice, but great injury, sometimes life-long in its consequences, is inflicted upon the babe at her breast that takes the intoxicating poison at second hand, and is influenced in a fourfold degree from its feebleness and great susceptibility.

Puberty.—For a certain period after birth, the sexual organs remain in a partially developed condition. This period varies in duration with different animals; in some cases being very brief, in others, comprising several years. Upon the attainment of a certain age, the individual becomes sexually perfect, and is then capable of the generative act. This period is called puberty. In man, puberty commonly occurs between the ages of ten and fifteen years, varying considerably in different climates. In this country, and in other countries of about the same latitude, puberty usually occurs at the age of fourteen or fourteen and one-half years in females, and a few months later in males. In cooler climates, as in Norway and Siberia, the change is delayed to the age of eighteen or nineteen years. In tropical climates it is hastened, occurring as early as nine or ten years. In warm climates it is no uncommon thing for a girl to be a mother at twelve; and it is stated that one of the wives of Mahomet was a mother at ten.

Other causes besides climate tend to hasten the occurrence of this change, as habits, temperament, constitutional tendency, education, and idiosyncrasy.

Habits of vigorous physical exercise tend to delay the access of puberty. For this reason, together with others, country boys and girls gen-

erally mature later by several months, and even a year or two, than those living in the city. Anything that tends to excite the emotions hastens puberty. The excitements of city life, parties, balls, theaters, even the competition of students in school, and the various causes of excitement to the nervous system which occur in city life, have a tendency to hasten the occurrence of the change which awakens the sexual activities of the system into life. Hence, these influences cannot but be considered prejudicial to the best interests of the individual, mentally, morally, and physically, since it is in every way desirable that a change which arouses the passions and gives to them greater intensity should be delayed rather than hastened.

Influence of Diet on Puberty.—The dietary has a not unimportant influence in this respect. Stimulating food, such as pepper, vinegar, mustard, spices, and condiments generally, together with tea and coffee, and an excess of animal food, have a clearly appreciable influence in inducing the premature occurrence of puberty. On this account, if on no other, should these articles be prohibited to children and youth, or used very sparingly. Those who advocate the large use of meat by children and youth have not studied this matter closely in all its bearings. While it is true that children and growing youth require an abundance of the nitrogenous elements of food, which are found abundantly in beefsteak, mutton, fish, and other varieties of animal food, it is also true that in taking those articles of food they take along with the nutrient elements properties of a stimulating character, which exert a decidedly detrimental influence upon the susceptible systems of children and youth. At the same time, it is possible to obtain the same desirable nitrogenous elements in oatmeal, unbolted wheat flour, peas, beans, and other vegetable productions, which are wholly free from injurious properties. We are positive from numerous observations on this subject, that a cool, unstimulating, vegetable or farinaceous diet would deter the development of the sexual organism for several months, and perhaps for a year or two.

While it may not be in all cases desirable to do this, it would at least be wise to adopt such measures in cases in which the child is unavoidably exposed to influences which have a tendency to hasten the change.

It is important to add in this connection a word of caution against the adoption of a dietary too abstemious in character. It is necessary that an abundance of good, wholesome food, rich in the elements of nutrition, should be taken regularly. There is no doubt that many young ladies have induced conditions of serious disease by actual starvation of

the system. A young woman who attempts to live on strong tea or coffee, fine-flour bread, and sweet-cake, is as certainly starving herself as though she were purposely attempting to commit suicide by means of starvation, and with as much certainty of the same result.

Cases occasionally occur in which puberty makes its appearance at the age of three or four years. Indeed, a case has been reported in this country in which a female child possessed all the characteristics which are usually developed at puberty, from birth. In this case the regular periodical changes began at birth.

Premature Development Occasions Early Decay.—A fact which is of too great importance to allow to pass unnoticed, is that whatever occasions early or premature sexual development, also occasions premature decay. Females in whom puberty occurs at the age of ten or twelve, by the time this age is doubled, are shriveled and wrinkled with age. At the time when they should be in their prime of health and beauty, they are prematurely old and broken. Those women who mature late retain their beauty and their strength many years after their precocious sisters have become old, decrepit, and broken down. Thus, the matrons of thirty and forty years in colder climates are much more attractive in appearance than the maidens of sixteen; while quite the reverse is true in this and other countries where sexual development is unduly hastened.

The unnaturally early appearance of puberty is a just cause for apprehension, since it usually indicates an inherent weakness of the constitution. When there are reasons for fearing its occurrence, active measures should be taken to occasion delay if possible. We call especial attention to this point, since there are many who erroneously suppose the early occurrence of puberty to be a sign of superior vigor.

Changes which Occur at Puberty.—The changes which occur in the two sexes at this period have been thus well described :—

"In both sexes, hair grows on the skin covering the *symphysis pubis*, around the sexual organs, and in the axillæ (armpits). In man, the chest and shoulders broaden, the larynx enlarges, and the voice becomes lower in pitch from the elongation of the vocal cords; hair grows upon the chin, upper lip, and cheeks, and often exists upon the general surface of the body more abundantly than in woman." The sexual organs undergo enlargement, and are more frequently excited. The testicles first begin the secretion of the seminal fluid.

"In woman, the pelvis and abdomen enlarge, but the whole frame

remains more slender, the muscles and joints less prominent, the limbs more rounded and tapering [than in the male]. Locally, both external and internal organs undergo a considerable and rapid enlargement. The mammæ enlarge, the ovarian vesicles become dilated, and there is established a periodical discharge of one or more ova, accompanied, in most cases, by a sanguineous fluid from the cavity of the uterus."

These changes, so varied and extraordinary, often occur within a very short space of time; and as they are liable to serious derangement, especially in the female, great care should be taken to secure for the individual the most favorable conditions until they are successfully effected. It is, however, a fact deserving of mention, that many of the ills which are developed at this particular period are quite as much the result of previous indiscretions and mismanagement as of any immediate cause. A few suggestions with regard to the proper treatment of individuals at this age may be in place.

1. Do not allow the boy or girl to be overworked, either mentally or physically. Great and important changes are occurring within the body, and nature should not be overtaxed.

2. Keep the mind occupied. While excessive labor should be avoided, idleness should be as carefully shunned. Some light, useful employment or harmless amusement—better some kind of work—should keep the mind fully occupied with wholesome subjects.

3. Abundant exercise out-of-doors is essential for both sexes. Sunshine and fresh air are as necessary to the development of a human being as for the expanding of a flower bud.

4. Watch carefully the associations of the youth. This should be done at all times, but especially just at the critical period in question, when the general physical disturbances occurring in the system react upon the mind and make it peculiarly susceptible to influences, especially those of an evil character.

5. None too much care can be exercised at this important epoch of human life, provided it is properly applied; but nothing could be more disastrous in its consequences than a weak solicitude which panders to every whim and gratifies every perverted appetite. *Such* care is a fatal error.

Menstruation.—The functional changes which occur in the female are much more marked than those of the male. As already intimated, the periodical development and discharge of an ovum by the female, which occurs after puberty, is accompanied by the discharge of a bloody

fluid, which is known as the *flowers, menses,* or *catamenia.* The accompanying symptoms together are termed the process of *menstruation,* or *being unwell.* This usually occurs, in the human female, once in about four weeks. In special cases, the interval may be a week less or a week longer; or the variation may be even greater. Dalton describes the process as follows:—

"When the expected period is about to come on, the female is affected by a certain degree of discomfort and lassitude, a sense of weight in the pelvis, and more or less disinclination to society. These symptoms are in some cases slightly pronounced, in others more troublesome. An unusual discharge of vaginal mucus then begins to take place, which soon becomes yellowish or rusty brown in color, from the admixture of a certain proportion of blood; and by the second or third day, the discharge has the appearance of nearly pure blood. The unpleasant sensations which were at first manifest, then usually subside; and the discharge, after continuing for a certain period, begins to grow more scanty. Its color changes from a pure red to a brownish or rusty tinge, until it finally disappears altogether, and the female returns to her ordinary condition."

The menstrual function continues active from puberty to about the forty-fifth year, or during the period of fertility. When it finally disappears, the woman is no longer capable of bearing children. The time of disappearance is termed the "change of life," or *menopause.* Exceptional cases occur in which this period is greatly hastened, arriving as early as the thirty-fifth year, or even earlier. Instances have also been observed in which menstruation continued as late as the sixtieth year, and even later; but such cases are very rare; and if procreation occurs, the progeny is feeble and senile.

With rare exceptions, the function is suspended during pregnancy, and usually, also, during the period of nursing.

Nature of Menstruation.—There has been a great amount of speculation concerning the cause and nature of the menstrual process. No entirely satisfactory conclusions have been reached, however, except that it is usually accompanied by the maturation and expulsion from the ovary of an ovum, which is termed ovulation. But menstruation may occur without ovulation, and *vice versa.*

Menstruation is not peculiar to the human female, being represented in the higher animals by what is familiarly termed the "rut." This is not usually a bloody discharge, however, as in the human female, though such a discharge has been observed in the monkey.

It has been quite satisfactorily settled that the discharge of the ovum from the ovary generally takes place about the time of the cessation of the flow. Immediately after the discharge, the sexual desires of the female are more intense than at other times. This fact is particularly manifest in lower animals. The following remark by Prof. Dalton is especially significant to those who care to appreciate its bearing:—

"It is a remarkable fact, in this connection, that the female of these [domestic] animals will allow the approaches of the male only during and immediately after the œstrual period [rut]; that is, just when the egg is recently discharged, and ready for impregnation. At other times, when sexual intercourse would be necessarily fruitless, the instinct of the animal leads her to avoid it; and the concourse of the sexes is accordingly made to correspond in time with the maturity of the egg and its aptitude for fecundation."

The amount of fluid lost during the menstrual flow varies greatly with different individuals. It is estimated at from three ounces to half a pint. In cases of deranged function, it may be much greater than this. It is not all blood, however, a considerable portion being mucus. It is rather difficult to understand why the discharge of so considerable a quantity of blood is required. There is no benefit derived from a very copious discharge, as some suppose. Facts seem to indicate that in general those enjoy the best health who lose but small quantities of blood in this manner.

As the first occurrence of menstruation is a very critical period in the life of a female, and as each recurrence of the function renders her especially susceptible to morbid influences, and liable to serious derangements, a few hints respecting the proper care of an individual at these periods may be acceptable.

Important Hints.—1. Avoid taking cold. To do this, it is necessary to avoid exposure; not that a person must be constantly confined in a warm room, for such a course would be the surest way in which to increase the susceptibility to cold. Nothing will disturb the menstrual process more quickly than a sudden chilling of the body when in a state of perspiration, or after confinement in a warm room, by exposure, without sufficient protection, to cold air. A daily bath and daily exercise in the open air are the best known means of preventing colds.

2. Intense mental excitement, as well as severe physical labor, is to be sedulously avoided during this period. At the time of its first

occurrence, special care should be observed in this direction. Intense study, a fit of anger, sudden grief, or even great merriment, will sometimes arrest the process prematurely. The feeling of *malaise* which usually accompanies the discharge is by nature intended as a warning that rest and quiet are required; and the hint should be followed. Every endeavor should be made to keep the individual comfortable, calm, and cheerful. Feelings of apprehension arising from a continual watching of symptoms are very depressing, and should be avoided by occupying the mind in some agreeable manner not demanding severe effort, either mental or physical.

There is no doubt that many young women have permanently injured their constitutions while at school by excessive mental taxation during the catamenial period, to which they were prompted by ambition to excel, or were compelled by the "cramming" system too generally pursued in our schools, and particularly in young ladies' seminaries. It is not to be supposed, however, that the moderate amount of sound study required by a correct system of teaching would be injurious to a healthy young woman at any time, and we have no doubt that a very large share of the injury which has been attributed to over-study during the catamenia has been induced by other causes, such as improper dress, exposure to taking cold, keeping late hours, and improper diet.

If there is any class of persons deserving of pity it is that large class of girls and young women who are in every large city employed as clerks, seamstresses, flower-makers, and in other taxing and confining occupations. In order to keep their situations they are required to be on hand daily, being allowed no opportunity for rest at the menstrual period. In many cases, too, they are compelled to remain upon their feet all day behind a counter, or at a work table, even at periods when a recumbent position is actually demanded by nature. There should be less delicacy in relation to this subject on the part of young women, and more consideration on the part of employers. Here is a field for philanthropic labor which is well worthy of the best efforts of any person of influence who will engage in it.

Custom of Indian Women.—The ease with which Indian women perform the parturient act is proverbial. They suffer scarcely at all from the pains of childbirth; and without doubt one reason of this is the preservation of their sexual health by rest during the menstrual period. At those seasons they invariably absent themselves from the

lodge, and enjoy absolute rest. We may readily suppose, from the nature of some of the Mosaic laws, that a custom somewhat similar prevailed among the ancient Hebrew women. If the hardy women of the forest are benefited by rest, certainly our more delicate females may be thus benefited. All need a degree of rest; with some it should be absolute.

The reckless manner in which some young women treat themselves at the menstrual period, is quite appalling to one who is acquainted with the painful and inveterate character of the evils which arise from such abuse. It is no uncommon thing for young ladies to attend balls, visit skating rinks, and otherwise expose themselves to influences in every way the best calculated to do them the most harm at this particular period, observing not the slightest precaution. Such recklessness is really criminal; and the sad consequences of physical transgression are sure to follow. A young lady who allows herself to get wet or chilled, or gets the feet wet, just prior to or during menstruation, runs the risk of imposing upon herself life-long injury. Mothers should look carefully after their daughters at these periods, and impress upon them the importance of special care.

3. A third hint, which is applicable to both sexes and at all times, is the necessity of attending promptly to the demands of nature for relief of the bowels and bladder. School-girls are often very negligent in this respect; and we have seen the most distressing cases of disease which were entirely attributable to this disregard of the promptings of nature. Obstinate constipation and chronic irritation of the bladder are common effects. When constipation results, purgatives in the shape of pills, salts, or "pleasant purgative pellets," are resorted to with the certain result of producing only temporary relief, and permanent damage.

To escape these evil consequences, do this: 1. Establish a regular habit of relieving the bowels daily at a certain hour; 2. Discard laxative and cathartic drugs of every kind; 3. To aid in securing a regular movement of the bowels, make a liberal use of oatmeal, wheatmeal, fruit, and vegetables, avoiding fine-flour bread, sweetmeats, and condiments; 4. Take daily exercise, as much as possible short of fatigue; if necessarily confined in-doors, counteract the constipating influence of sedentary habits by kneading and percussing the bowels with the hands several minutes each day; 5. Never resist the calls of nature a single moment, if possible to avoid it. In this case, as in

numerous others, "delay is dangerous." Ladies who desire a sweet breath—and what lady does not—should remember that retained feces are one of the most frequent causes of foul breath. The foul odors which ought to pass out through the bowels find their way into the blood and escape at the lungs.

It is of the greatest importance that careful attention should be given to the proper establishment of the menstrual function at the outset of a woman's life of sexual activity. The first two years will be quite likely to have a deciding influence respecting her health during her whole future life. If a woman can get through the first two years after puberty without acquiring any serious uterine or ovarian disease, she will stand a good chance of enjoying a good degree of sexual health during the balance of her life. The foundation of a great share of the many thousands of cases of uterine disease is laid during this period.

At this early period the daughter is usually too young to appreciate the importance of observing slight deviations from the standard of health, even if she were able to recognize them. Hence it is a duty which no mother should neglect, to inquire into the exact frequency of the periods, the amount and character of the discharge, and other points necessary to ascertain whether or not there is any deviation from the natural condition of health. If there is pain, it is a certain evidence of something seriously wrong. If there is irregularity in any particular, it is a matter well deserving of serious attention.

Extra-Uterine Pregnancy.—Sometimes the ovum becomes fecundated before reaching the uterus, and instead of passing onward into that organ as usual, remains in its position in the Fallopian tube or even on the surface of the ovary. Occasionally an ovum falls into the cavity of the abdomen instead of passing into the tube. Even in this situation it may be fecundated. Impregnated ova, thus left in abnormal positions, sometimes undergo a greater or lesser degree of development. They often result in the death of the mother.

Twins.—The human female usually matures but one ovum at each menstrual period, the two ovaries acting alternately. Occasionally two ova are matured at once. If fecundation occurs, the result will be a development of two embryos at the same time. In rare cases, three or even four ova are matured at once, and by fecundation produce a corresponding number of embryos. As many as five children have been born alive at one birth, but have not usually lived more than a few minutes.

Monsters.—Defects and abnormalities in the development of the embryon produce all degrees of deviation from the typical human form. Excessive development may result in an extra finger or toe, or in the production of some peculiar excrescence. Deficiency of development may produce all degrees of abnormality from the simple harelip to the most frightful deficiency, as the absence of a limb, or even of a head. It is in this manner that those unfortunate individuals known as her-

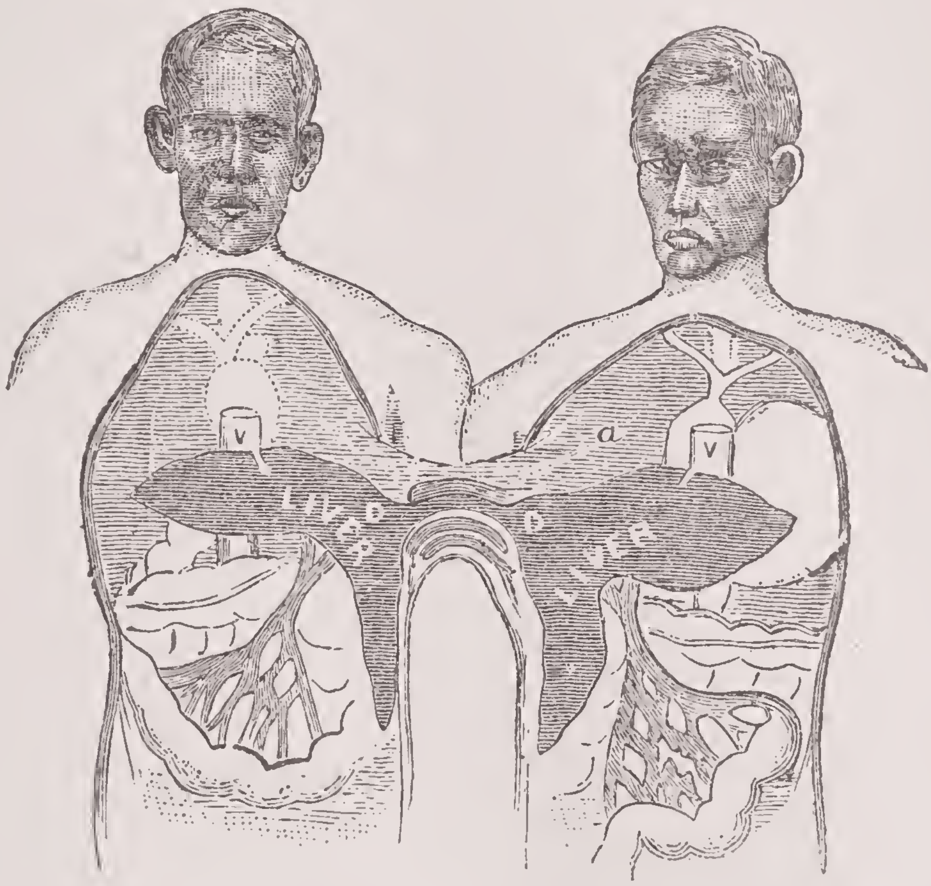


Fig. 139. Chang and Eng, the Siamese Twins.

maphrodites are formed. An excessive development of some parts of the female generative organs gives them a great degree of similarity to the external organs of the male. A deficient development of the masculine organs renders them similar in appearance to those of the female. Excessive development shown in a peculiar manner produces both kinds of organs in the same individual in a state more or less complete.

The uncouth shapes which are sometimes supposed to be the result of amalgamation with lower animals are produced in essentially the same manner. The stories which are frequently told of women giving birth to puppies and other animals have no foundation other than that mentioned.

Such curious cases as the Carolina twins and Chang and Eng were formerly supposed to be the result of the union of two separate individuals. It is now believed that they are developed from a single ovum.

Hybrids.—It is a well-known law of biology that no progeny result from union of animals of different species. Different varieties of the same species may in some cases form a fertile union, the result of which is a cross between its two parents, possessing some of the qualities of each. The mule is the product of such a union between the horse and the ass. A curious fact is that the offspring of such unions are themselves sterile almost without exception. The reason of this is that they do not produce mature elements of generation. In the mule, the zoösperms are either entirely absent or else very imperfectly developed; hence the fact that a colt having a mule for its sire is one of the rarest of curiosities, though a few instances have been reported. This is a wise law of nature to preserve the purity of species.

Law of Sex.—If there is a law by which the sex of the developing embryon is determined, it probably has not yet been discovered. The influence of the will, the predominant vitality of one or the other of the parents, and the period at which conception occurs, have all been supposed to be the determining cause. A German physician some time since advanced the theory that the two testicles and ovaries produce elements of different sexual character, the right testicle forming zoösperms capable of producing only males, and the right ovary producing ova with the same peculiarity. The left testis and the left ovary he supposed to form the female elements. He claimed to have proved his theory by experiments upon animals. Even if true, this theory will not be made of practical importance. It is, in fact, nothing more than a revival of an old theory held by physicians who flourished more than two thousand years ago.

More recently, another German physician has advanced the theory that the sex may be controlled at will by observing the time of fecundation. He asserts that when fecundation occurs shortly after menstruation, the result will be a female; but if impregnation occurs later in the month, and prior to the three or four days preceding the next menstrual period, a male will almost certainly be produced. This theory was proposed by Prof. Thury of the academy of Geneva, who claims to have thoroughly tested it in a great variety of ways, and always with an affirmative result. Dr. Heitzman, of New York, an instructor in pathological histology, and an eminent physiologist, informs us that he has thoroughly tested this theory, and finds it to be entirely reliable. There are numerous facts which seem to corroborate the truth of this theory, and future investigations may give to it the dignity of an established physiological fact.

Heredity.—The phenomena of heredity are among the most interesting of biological studies. It is a matter of common observation that a child looks like its parents. It even happens that a child resembles an uncle or a grandparent more nearly than either parent. The same peculiarities are often seen in animals.

The cause of this resemblance of offspring to parents and ancestors has been made a subject of careful study by scientific men. We shall present the most recent theory adopted, which, although it be but a theory, presents such an array of facts in its support, and explains the phenomena in question so admirably, that it must be regarded as something more than a plausible hypothesis. It is the conception of one of the most distinguished scientists of the age. The theory is known as the doctrine of *pangenesis*, and is essentially as follows :—

It is a fact well known to physiologists that every part of the living body is made up of cellular elements which have the power to reproduce themselves in the individual, thus repairing the damage resulting from waste and injury. Each cell produces cells like itself. It is further known that there are found in the body numerous central points of growth. In every group of cells is found a central cell from which the others originated, and which determines the form of their growth. Every minute structure possesses such a center. A simple proof of this fact is found in the experiment in which the spur of a cock was grafted upon the ear of an ox. It lived in this novel situation eight years, attaining the length of nine inches, and nearly a pound in weight. A tooth has been made to grow upon the comb of a cock in a similar manner. The tail of a pig survived the operation of transplanting from its proper position to the back of the animal, and retained its sensibility. Numerous similar illustrations might be given.

The doctrine of pangenesis supposes that these centers of nutrition form and throw off not only cells like themselves, but very minute granules, called gemmules, each of which is capable, under suitable circumstances, of developing into a cell like its parent.

These minute granules are scattered through the system in great numbers. The essential organs of generation, the testicles in the male and the ovaries in the female, perform the task of collecting these gemmules and forming them into sets, each of which constitutes a reproductive element, and contains, in rudimentary form, a representative of every part of the individual, including the most minute peculiarities.

Even more than this : It is supposed that each ovum and each zoösperm contains not only the gemmules necessary to reproduce the individuals who produced them, but also a number of gemmules which have been transmitted from the individuals' ancestors.

If this theory be true,—and we can see no sound objection to it,—it is easy to understand all the problems of heredity. The gemmules must be very small indeed, but it may be suggested that the molecules of matter are smaller still, so this fact is no objection to the theory.

It will be seen, then, that each spermatozoön, or zoösperm, actually contains, in an embryonic condition, every organ and tissue of the individual producing it. The same is true of the ovum. In other words, the reproductive elements are complete representatives, in miniature, of the parents, and contain all the elements for producing an offspring possessing the same peculiarities as the parents. Various modifying circumstances sufficiently explain the dissimilarities between parents and children.

This theory is strikingly confirmed by the fact, previously mentioned, that in certain cases the ovum alone, a single reproductive element, may undergo a degree of development approaching very near to completion. It is supposed that fecundation is chiefly necessary to give to the gemmules the requisite amount of nourishment to insure development.

As we shall see hereafter, this matter has a very important bearing upon several practical questions.

Ante-Natal Influences.—There can be no manner of doubt that many circumstances which it is entirely within the power of the parents to supply, exert a powerful influence in molding both the mental and the physical characteristics of offspring. By carefully availing himself of the controlling power given him by a knowledge of this fact, the stock-raiser is enabled to produce almost any required quality in his young animals. Pigeon fanciers show wonderful skill in thus producing most curious modifications in birds. The laws of heredity and development are carefully studied and applied in the production of superior horses, cows, dogs, and pigeons; but an application of the same principles to the improvement of the human race is rarely thought of. Human beings are generated in as haphazard and reckless a manner as weeds are sown by the wind. No account is taken of the possible influence which may be exerted upon the future destiny of the new being by the physical or mental condition of parents at the moment when the germ of life is planted, or by the mental and physical conditions and

surroundings of the mother while the young life is developing. Indeed, the assertion of a modern writer that the poor of our great cities virtually "spawn children," with as little thought of influences and consequences as the fish that sow their eggs broadcast upon the waters, is not so great an exaggeration as it might at first sight appear to be.

Men and women are constantly prone to forget that the domain of law is universal. Nothing comes by chance. The revolutions of the planets, studied by the aid of the telescope, and the gyrations of the atoms, seen only by the eye of science, are alike examples of the controlling influence of law. Notwithstanding this sad ignorance and disregard of this vitally important subject, the effects of law are only too clearly manifested in the crowds of wretched human beings with which the world is thronged. An old writer sagely remarks, "It is the greatest part of our felicity to be well born;" nevertheless, it is the sad misfortune of by far the greater portion of humanity to be deprived of this inestimable "felicity."

It is an established physiological fact that the character of offspring is influenced by the mental as well as the physical conditions of the parents at the moment of the performance of the generative act. In view of this fact, how many parents can regard the precocious—or even mature—manifestations of sexual depravity in their children without painful smitings of conscience at seeing the legitimate results of their own sensuality? By debasing the reproductive function to an act of selfish animal indulgence, they imprinted upon their children an almost irresistible tendency to vice. Viewing the matter from this stand-point, what wonder that licentiousness is rife! that true chastity is among the rarest of virtues!

Prof. O. W. Holmes remarks on this subject: "There are people who think that everything may be done if the doctor, be he educator or physician, be only called in season. No doubt; but *in season* would often be a hundred or two years before the child was born, and people never send so early as that." "Each of us is only the footing up of a double column of figures that goes back to the first pair. Every unit tells, and some of them are *plus* and some *minus*. If the columns don't add up right, it is commonly because we can't make out all of the figures."

It cannot be doubted that the throngs of deaf, blind, crippled, idiotic unfortunates who were "born so," together with a still larger class of dwarfed, diseased, and constitutionally weak individuals, are the lamentable results of the violation of some sexual law on the part of their progenitors.

If parents would stop a moment to consider the momentous responsibilities involved in the act of bringing into existence a human being; if they would reflect that the qualities imparted to the new being will affect its character to all eternity; if they would recall the fact that they are about to produce a mirror in which will be reflected their own characters divested of all the flimsy fabrics which deceive their fellow-men, revealing even the secret imaginings of their hearts,—there would surely be far less of sin, disease, and misery born into the world than at the present day; but we dare not hope for such a reform. To effect it, would require such a revolution in the customs of society, such a radical reform in the habits and characters of individuals, as nothing short of a temporal millennium would be able to effect.

SEXUAL HYGIENE.

Under this head we will consider some of the more general subjects relating to the health of the reproductive organism which have not been considered in connection with the special organs and functions described.

The *use* of the reproductive function is perhaps the highest physical act of which man is capable, its *abuse* is certainly one of the most grievous outrages against nature which it is possible for him to perpetrate. No observing person can doubt that the sexual relations of men and women determine in a great degree their happiness or misery in life. This subject, then, deserves due attention and careful consideration. It is of no use to scout it; for it will inevitably obtrude itself upon us, no matter how sedulously we attempt to avoid it. It can be rightly considered only with the most perfect candor, with the mind unbiased by passion, and prayerfully anxious to know and *do* what is right.

In the following paragraphs of this section are considered some of the evils out of which grows much of the sexual suffering of men and women:—

Sexual Precocity.—There are two periods in human life when the sexual instincts should be totally dormant; and they are so when nature is not perverted. The first is the period reaching from infancy to puberty. The second is the period reached in advanced age.

If raised strictly in accordance with natural law, children would have no sexual notions or feelings before the occurrence of puberty. No prurient speculation about sexual matters would enter their heads. Until that period, the reproductive system should lie dormant in its

undeveloped state. No other feeling should be exhibited between the sexes than that brotherly and sisterly affection which is so admirable and becoming.

Fortunate, indeed, would it be for humanity if this natural state always existed; but it is a lamentable fact that it is rarely seen in modern homes. Not infrequently, evidences of sexual passion are manifested before the child has hardly learned to walk. It has been suggested that this precocity is nothing remarkable or unnatural, since it is often seen in little lambs and other young animals. To this it is only necessary to reply that the development of the sexual instincts perfectly corresponds with the longevity of the animal; if short-lived, like the sheep, only a short period intervenes between birth and the attainment of the sexual appetite and virility. If the animal is intended for long life, as is the case with man, these manifestations are delayed, or should be, until a much later period.

Dr. Acton, a distinguished English surgeon, makes the following excellent remarks upon this subject:—

"Slight signs are sufficient to indicate when a boy has this unfortunate tendency. He shows marked preferences. You will see him single out one girl, and evidently derive an unusual pleasure (for a boy) in her society. His *penchant* does not take the ordinary form of a boy's good nature, but little attentions that are generally reserved for a later period prove that his feeling is different, and sadly premature. He may be apparently healthy, and fond of playing with other boys; still there are slight, but ominous, indications of propensities fraught with danger to himself. His play with the girl is different from his play with his brothers. His kindness to her is a little too ardent. He follows her, he does not know why. He fondles her with a tenderness painfully suggestive of a vague dawning of passion. No one can find fault with him. He does nothing wrong. Parents and friends are delighted at his gentleness and politeness, and not a little amused at the early flirtation. If they were wise, they would rather feel profound anxiety; and he would be an unfaithful or unwise medical friend who did not, if an opportunity occurred, warn them that such a boy, unsuspicious and innocent as he is, ought to be carefully watched and removed from every influence calculated to foster his abnormal propensities."

We have been not more disgusted than shocked to see parents, whose intelligence ought to teach them better, not only winking at,

but actually encouraging, these premature manifestations of passion in their children. They may yet learn, by bitter experience, the folly of their course, unless they make the discovery in time to avert, by careful reformatory training, the calamitous results which threaten the future of their children.

Chastity.—In Ex. 20 : 14 and Matt. 5 : 28 we have a complete definition of chastity. The seventh commandment, with the Saviour's commentary upon it, places clearly before us the fact that chastity requires purity of thought as well as of outward acts. Impure thoughts and unchaste acts are alike violations of the seventh commandment. As we shall see, also, unchastity of the mind is a violation of natural law as well as of moral law, and is visited with physical punishment commensurate to the transgression.

Mental Unchastity.—It is vain for a man to suppose himself chaste who allows his imagination to run riot amid scenes of amorous associations. The man whose lips delight in tales of licentiousness, whose eyes feast upon obscene pictures, who is ever ready to pervert the meaning of a harmless word or act into uncleanness, who finds delight in reading vivid portrayals of acts of lewdness,—such a one is not a virtuous man.

Man may not see these mental adulteries, he may not perceive these filthy imaginings; but One sees and notes them. They leave their hideous scars upon the soul. They soil and mar the mind; and as the record of each day of life is photographed upon the books in Heaven, they each appear in bold relief, in all their innate hideousness.

Foul thoughts once allowed to enter the mind, stick like the leprosy. They corrode, contaminate, and infect like the pestilence; naught but Almighty power can deliver from the bondage of concupiscence a soul once infected by this foul blight, this moral contagium.

It is a wide-spread and deadly error, that only outward acts are harmful; that only physical transgression of the laws of chastity will produce disease. We have seen all the effects of beastly abuse result from mental sin alone.

"I have traced serious affections and very great suffering to this cause. The cases may occur at any period of life. We meet with them frequently among such as are usually called, or think themselves, continent young men. There are large classes of persons who seem to think that they may, without moral guilt, excite their own feelings or those of others by loose or libidinous conversation in soci-

ety, provided such impure thoughts or acts are not followed by masturbation or fornication. I have almost daily to tell such persons that physically, and in a sanitary point of view, they are ruining their constitutions. There are young men who almost pass their lives in making carnal acquaintances in the street, but just stop short of seducing girls; there are others who haunt the lower classes of places of public amusement for the purpose of sexual excitement, and live, in fact, a thoroughly immoral life in all respects except actually going home with prostitutes. When these men come to me, laboring under the various forms of impotence, they are surprised at my suggesting to them the possibility of the impairment of their powers being dependent upon these previous vicious habits."*

"Those lascivious *day-dreams* and amorous reveries, in which young people—and especially the idle and the voluptuous, and the sedentary and the nervous—are exceedingly apt to indulge, are often the sources of general debility, effeminacy, disordered functions, premature disease and even premature death, without the actual exercise of the genital organs; Indeed, this unchastity of thought—this adultery of the mind—is the beginning of immeasurable evil to the human family." †

"Filthy dreamers," before they are aware, become filthy in action. The thoughts mold the brain, as certainly as the brain molds the thoughts. Rapidly down the current of sensuality is swept the individual who yields his imagination to the contemplation of lascivious themes. Before he knows his danger, he finds himself deep in the mire of concupiscence. He may preserve a fair exterior; but deception cannot cleanse the slime from his putrid soul. How many a church member carries under a garb of piety a soul filled with abominations, no human scrutiny can tell. How many pulpits are filled by "whited sepulchers," only the Judgment will disclose.

Early Causes.—The earliest of all causes is hereditary predisposition. As we have shown, a child conceived in lust can no more be chaste by nature than a negro can be a Caucasian. But back of this there is a deeper cause, as we shall see, one that affects parents as well as offspring. Between infancy and puberty, are in operation all those influences mentioned under "Sexual Precocity."

The frequent custom of allowing children of opposite sex to

* Acton. † Graham.

sleep together, even until eight or ten years of age, or longer, is a dangerous one. We have known of instances in which little boys of seven or eight have been allowed to sleep with girls of fourteen or sixteen, in some of which most shameful lessons were taught, and by persons who would not be suspected of such an impropriety. In one instance a little boy of eight, occupying the same bed with three girls several years older, was used for illustration by the older girl in instructing the younger ones in the *modus operandi* of reproduction. The sexes should be carefully separated from each other at least as early as four or five years of age, under all circumstances which could afford opportunity for observing the physical differences of the sexes, or in any way serve to excite those passions which at this tender age should be wholly dormant.

Diet vs. Chastity.—From earliest infancy to impotent old age, under the perverting influence of civilization, there is a constant antagonism between diet and purity. When old enough to take food in the ordinary way, the infant's tender organs of digestion are plied with highly seasoned viands, stimulating sauces, animal food, sweetmeats, and dainty tidbits in endless variety. Soon, tea and coffee are added to the list. Salt, pepper, ginger, mustard, condiments of every sort, deteriorate his daily food. If, perchance, he does not die at once of indigestion, or with his weakened forces fall a speedy victim to the diseases incident to infancy, he has his digestive organs impaired for life at the very outset of his existence.

Exciting stimulants and condiments weaken and irritate his nerves and derange the circulation. Thus, indirectly, they affect the sexual system, which suffers through sympathy with the other organs. But a more direct injury is done. Flesh, condiments, eggs, tea, coffee, chocolate, and all other stimulants, have a powerful influence directly upon the reproductive organs. They increase the local supply of blood; and through nervous sympathy with the brain, the passions are aroused.

Overeating, eating between meals, hasty eating, eating indigestible articles of food, late suppers, react upon the sexual organs with the utmost certainty. Any disturbance of the digestive function deteriorates the quality of the blood. Poor blood, filled with crude, poorly digested food, is irritating to the nervous system, and especially to those extremely delicate nerves which govern the reproductive function. Irritation provokes congestion; congestion excites sexual de-

sires; excited passions increase the local disturbance; and thus each reacts upon the other, ever increasing the injury and the liability to future damage.

Thus, these exciting causes continue their insidious work through youth and more mature years. Right under the eyes of fathers and mothers they work the ruin of their children, exciting such storms of passion as are absolutely uncontrollable.

Tobacco and Vice.—Few are aware of the influence upon morals exerted by that filthy habit, tobacco-using. When acquired early, it excites the undeveloped organs, arouses the passions, and in a few years converts the once chaste and pure youth into a veritable volcano of lust, belching out from its inner fires of passion torrents of obscenity and the sulphurous fumes of lasciviousness. If long-continued, the final effect of tobacco is emasculation; but this is only the necessary consequence of previous super-excitation.

We are aware that we have made a grave charge against tobacco, and we have not hesitated to state the naked truth; yet we do not think we have exaggerated, in the least, the pernicious influence of this foul drug. As much might be said against the use of liquor on the same grounds.

Bad Books.—Another potent enemy of virtue is the obscene literature which has flooded the land for many years. Circulated by secret agencies, these books have found their way into the most secluded districts. Every large school contains one or more of these emissaries of evil men and their Satanic master.

Largely through the influence of Mr. Anthony Comstock, laws have been enacted which promise to do much toward checking this extensive evil, or at least causing it to make itself less prominent. Our newspapers still abound with advertisements of various so-called medical works, "Marriage Guides," etc., which are fruits of the same "upas-tree" that Mr. Comstock has labored so faithfully to uproot.

It is a painful fact, however, that the total annihilation of every foul book which the law can reach will not effect the cure of this evil, for our modern literature is full of the same virus. It is necessarily presented in less grossly revolting forms, half concealed by beautiful imagery, or embellished by wit; but yet, there it is, and no law can reach it. The works of our standard authors in literature abound in lubricity. Popular novels have doubtless done more to arouse a prurient curiosity in the young, and to excite and foster passion and immorality, than even

the obscene literature for the suppression of which such active measures have recently been taken. The more exquisitely painted the scenes of vice, the more dangerously enticing. Novel-reading has led thousands to lives of dissoluteness.

Many other causes might be enumerated, as idleness, evil associations, etc., but we need not dwell longer on this point.

Unthought-of Excesses.—Sexual wrong exists among the married as well as the unmarried, and that within the pale of the marriage rite. Ignorant or regardless of the consequences, many married people give loose rein to their passions, supposing that the marriage vow removes all duty of restraint. Nature does not, however, forget to inflict upon the offenders commensurate punishment for their wrong-doing. A long list of diseases, affecting both males and females, might be presented as the direct consequences of this form of sexual transgression. Married people should recollect that the duty of restraint is as binding upon them after as before marriage.

Without stopping to consider the various circumstances under which absolute continence is expedient, or desirable, or morally required, we will proceed at once to examine the question, Is continence harmful?

Continence not Injurious.—It has been claimed by many, even by physicians,—and with considerable show of reason,—that absolute continence, after full development of the organs of reproduction, could not be maintained without great detriment to health. It is needless to enumerate all the different arguments employed to support this position, since they are, with a few exceptions, too frivolous to deserve attention. We shall content ourselves chiefly with quotations from acknowledged authorities, by which we shall show that the popular notions upon this subject are wholly erroneous. Their general acceptance has been due, without doubt, to the strong natural bias in their favor. It is an easy matter to believe what agrees well with one's predilections. A bare surmise on the side of prejudice, is more telling than the most powerful logic on the other side.

"We know that this opinion is held by men of the world, and that many physicians share it. This belief appears to us to be erroneous, without foundation, and easily refuted."*

The same writer claims "that no peculiar disease nor any abridg-

* Mayer.

ment of the duration of life can be ascribed to such continence." He proves his position by appealing to statistics, and shows the fallacy of arguments in support of the contrary view. He further says:—

"It is determined, in our opinion, that the commerce of the sexes has no necessities that cannot be restrained without peril."

"A part has been assigned to *spermatic plethora* in the etiology of various mental affections. Among others, priapism has been attributed to it. In our opinion, this malady originates in a disturbance of the cerebral nerve power; but it is due much less to the retention of sperm than to its exaggerated loss; much less to virtuous abstinence than to moral depravity."

There has evidently been a wide-spread deception upon this subject. "Health does not absolutely require that there should ever be an emission of semen, from puberty to death, though the individual live a hundred years; and the frequency of involuntary nocturnal emissions is an indubitable proof that the parts, at least, are suffering under a debility and morbid irritability utterly incompatible with the general welfare of the system."

Does not Produce Impotence.—It has been declared that strict continency would result in impotency. The falsity of this argument is clearly shown by the following observations:—

"There exists no *greater error* than this, nor one more opposed to physiological truth. In the first place, I may state that I have, after many years' experience, never seen a single instance of atrophy of the generative organs from this cause. I have, it is true, met the complaint, but in what class of cases does it occur? It arises, in all instances, from the exactly opposite cause, abuse; the organs become worn out, and hence arises atrophy. Physiologically considered, it is not a fact that the power of secreting semen is annihilated in well-formed adults leading a healthy life and yet remaining continent. No continent man need be deterred by this apocryphal fear of atrophy of the testes, from living a chaste life. It is a device of the unchaste,—a lame excuse for their own incontinence, unfounded on any physiological law." *

The truth of this statement has been amply confirmed by experiments upon animals.

The complaint is made by those whose lives have been far otherwise than continent, that abstinence occasions suffering, from which indul-

* Acton.

gence gives relief. The same writer further says that when such a patient consults a medical man, "he should be told—and the result would soon prove the correctness of the advice—that attention to diet, gymnastic exercise, and self-control, will most effectually relieve the symptoms."

Difficulty of Continence.—Some there are who urge that self-denial is difficult; that the natural promptings are imperious. From this they argue that it cannot but be right to gratify so strong a passion. "The admitted fact that continence, even at the very beginning of manhood, is frequently productive of distress, is often a struggle hard to be borne,—still harder to be completely victorious in,—is not to be at all regarded as an argument that it is an *evil*." *

But if rigid continence is maintained from the first, the struggle with the passions will not be nearly so severe as after they have once been allowed to gain the ascendency. On this point, the following remarks are very just:—

"At the outset, the sexual necessities are not so uncontrolled as is generally supposed, and they can be put down by the exercise of a little energetic will. There is, therefore, as it appears to us, as much injustice in accusing nature of disorders which are dependent upon the genital senses, badly directed, as there would be in attributing to it a sprain or a fracture accidentally produced." †

Helps to Continence.—As already indicated, and as every individual with strong passions knows, the warfare with passion is a serious one if one determines to lead a continent life. He needs the help of every aid that he can gain. Some of these may be named as follows:—

The Will.—A firm determination must be formed to lead a life of purity; to quickly quench the first suggestions of impurity; to harbor no unchaste desire; to purge the mind of carnal thoughts; in short, to cleave fast to mental continence. Each triumph over vicious thoughts will strengthen virtue; each victory won will make the next the easier. So strong a habit of continence may be formed that this alone will be a bulwark against vice.

Diet.—He who would keep in subjection his animal nature must carefully guard the portal to his stomach. The blood is made of what is eaten. Irritating food will produce irritating blood. Stimulating foods or drinks will surely produce a corresponding quality of blood.

* Ibid. † Mayer.

Irritating, stimulating blood will irritate and stimulate the nervous system, and especially the delicate nerves of the reproductive system, as previously explained. Only the most simple and wholesome food should be eaten, and that only in such moderate quantities as are required to replenish the tissues. The custom of making the food pungent and stimulating with condiments is the great, almost the sole, cause of gluttony. It is one of the greatest hindrances to virtue. Indeed, it may with truth be said that the devices of modern cookery are most powerful allies of unchastity and licentiousness. This subject is particularly deserving of careful, candid, and studious attention, and only needs such investigation to demonstrate its soundness.

Exercise.—Next to diet as an aid to continence, perhaps of equal importance with it, is exercise, both physical and mental. It is a trite proverb, the truth of which every one acknowledges, that "Satan finds some mischief still for idle hands to do," and it is equally true that he always has an evil thought in readiness—speaking figuratively—to instill into an unoccupied mind. A person who desires to be pure and continent in body and mind must flee idleness as he would the devil himself; for the latter is always ready to improve upon the advantages afforded by an idle moment, an hour given to reverie.

Walking, riding, rowing, and gymnastics are among the best modes of physical exercise for sedentary persons; but there is no better form of exercise than working in the garden. The cultivation of small fruits, flowers, and other occupations of like character, really excel all other modes of physical exercise for one who can engage in them with real pleasure. Dozing is bad at any time; for it is a condition in which the will is nearly dormant, though consciousness still lingers, and the imagination is allowed to run wild, and often enough it will run where it ought not. Late study, or late hours spent in any manner, is a sure means of producing general nervous irritability and sexual excitement through reflex influence.

Bathing.—A daily bath with cool or tepid water, followed by vigorous rubbing of the skin with a coarse towel and then with the dry hand, is a most valuable aid. The hour of first rising is generally the most convenient time. General and local cleanliness are indispensable to general and local health.

Religion.—After availing himself of all other aids to continence, if he wishes to maintain purity of mind as well as physical chastity,—and one cannot exist long without the other,—the individual must seek that

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most powerful and helpful of all aids, divine grace. If, in the conflict with his animal nature, man had only to contend with the degrading influences of his own propensities, the battle would be a serious one, and it is doubtful whether human nature alone—at least in any but rare cases—would be able to gain the victory; but, in addition to his own inherent tendencies to evil, man is assailed at every point by unseen agencies that seek to drag him down and spoil his soul with lust. These fiendish influences are only felt, not seen, from which some argue that they do not exist. Such casuists must find enormous depths for human depravity. But who has not felt the cruel power of these unseen foes? Against them, there is but one safe, successful weapon, "the blood of Christ which cleanseth from all sin."

The struggling soul, beset with evil thoughts, will find in prayer a salvation which all his force of will, and dieting and exercising, will not, alone, insure him. Yet prayer alone will not avail. Faith and works must always be associated. All that one can do to work out his own salvation, he must do; then he can safely trust in God to do the rest, even though the struggle seems almost a useless one; for when the soul has been long in bondage to concupiscence, the mind a hold of foul and lustful thoughts, a panorama of unchaste imagery, these hateful phantoms will even intrude themselves upon the sanctity of prayer, and make their victim mentally unchaste upon his knees. But Christ can pity even such; and even these degraded minds may yet be pure if with the psalmist they continue to cry, with a true purpose and unwavering trust, "Create in me a clean heart, O God, and renew a right spirit within me." "Purge me with hyssop, and I shall be clean; wash me, and I shall be whiter than snow."

At the first suggestion of an evil thought, send up a mental prayer to Him whose ear is always open. Prayer and impurity are as incompatible as oil and water. The pure thoughts that sincere prayer will bring, displace the evil promptings of excited passion. But the desire for aid must be sincere. Prayer will be of no avail while the mind is half consenting to the evil thought. The evil must be loathed, spurned, detested.

It would seem almost unnecessary to suggest the impropriety of resorting to prayer alone when sexual excitability has arisen from a culpable neglect to remove the physical conditions of local excitement by the means already mentioned. Such physical causes must be well looked after, or every attempt to reform will be fruitless. God requires

of every individual to do for himself all that he is capable of doing; to employ every available means for alleviating his sufferings.

Sexual Crimes.—The sexual crimes with which we wish to deal, as being those most seldom referred to, are prevention of conception, and intentional abortion. The first-mentioned, we are aware, is hardly considered a crime by the majority of people; and the same might be said respecting the second with large numbers of persons, though it is so recognized by the law. All medical authorities agree that prevention of conception, no matter by which one of the numerous methods commonly employed it may be induced, is always harmful and productive of disease. Personal experience in the medical care of a large number of ladies suffering with all forms of sexual derangements has enabled us to confirm this judgment many times. As it cannot be told at just what moment fecundation takes place, and as it may occur immediately, some of the methods employed for prevention plainly involve moral principles most seriously. It has been previously shown that in the ovum of the female, and the spermatozoön of the male, are, in rudimentary form, all the elements which go to make up the "human form divine." Alone, neither of these elements can become anything more than it already is; but the instant that the two elements come in contact fecundation takes place, and the individual life begins. From that moment until maturity is reached, years subsequently, the whole process is only one of development. Nothing absolutely new is added at any subsequent moment. In view of these facts, it is evident that at the very instant of conception the embryonic human being possesses all the right to life it ever can possess. It is just as much an individual, a distinct human being, possessed of soul and body, as it ever is, though in a very immature form. That conception may take place during the reproductive act cannot be denied. If, then, means are employed with a view to prevent conception immediately after the accomplishment of the act, or at any subsequent time, if successful, it would be by destroying the delicate product of the conception which had already occurred, and which, as before observed, is as truly a distinct individual as it can ever become—certainly as independent as at any time previous to birth.

Is it immoral to take human life? Is it a sin to kill a child? Is it a crime to strangle an infant at birth? Is it a murderous act to destroy a half-formed human being in its mother's womb? Who will dare to answer "No," to one of these questions? Then, who can re-

fuse assent to the plain truth that it is equally a murder to deprive of life the most recent product of the generative act?

Who can number the myriads of murders that have been perpetrated at this early period of existence? Who can estimate the load of guilt that weighs upon some human souls? and who knows how many brilliant lights have been thus early extinguished? how many promising human plantlets thus ruthlessly destroyed in the very act of germinating? It is to be hoped that in the final account the extenuating influence of ignorance may weigh heavily in the scale of justice against the damning testimony of these "unconsidered murders."

Criminal Abortion.—Few but medical men are aware of the enormous proportions which have been assumed by this terrible crime during the present century. That it is increasing with fearful rapidity and has really reached such a magnitude as to seriously affect the growth of civilized nations, and to threaten their very existence, has become a patent fact to observing physicians.

An eminent medical author asserts "that the frequency of this form of destroying human life exceeds all others by at least fifty per cent, and that not more than one in a thousand of the guilty parties receive any punishment by the hand of civil law. But there is a surer mode of punishment for the guilty mother in the self-executing laws of nature."

The destruction of the child after the mother has felt its movements is termed infanticide; before that time it is commonly known as abortion. It is a modern notion that the child possesses no soul or individual life until the period of quickening, an error which we have already sufficiently exposed. The ancients, with just as much reason, contended that no distinct life was present until after birth. Hence it was that they could practice without scruple the crime of infanticide to prevent too great increase of population.

The effects of this crime are not upon the child alone. The mother suffers not only imminent peril of life at the time, but the almost certain penalty of chronic invalidism the remainder of her life. We have good authority for the assertion that abortion is *fifteen times as dangerous* as natural childbirth. With reference to the immorality of the act the eminent author of "The Ten Laws of Health" says:—

"There are those who would fain make light of this crime by attempting to convince themselves and others that a child, while in embryo, has only a sort of vegetative life, not yet endowed with

thought, and the ability to maintain an independent existence. If such a monstrous philosophy as this presents any justification for such an act, then the killing of a newly-born infant, or of an idiot, may be likewise justified. The destruction of the life of an unborn human being, for the reason that it is small, feeble, and innocently helpless, rather aggravates than palliates the crime. Every act of this kind, with its justification, is obviously akin to that savage philosophy which accounts it a matter of no moment, or rather a duty, to destroy feeble infants, or old, helpless fathers and mothers."*

"From a very large verbal and written correspondence in this and other States, I am satisfied that we have become *a nation of murderers.*"†

Said a distinguished clergyman of Brooklyn in a sermon, "Why send missionaries to India when child-murder is here of daily, almost hourly occurrence; aye, when the hand that puts money into the contribution-box to-day, yesterday or a month ago, or to-morrow, will murder her own unborn offspring?"

Whether this gigantic evil can ever be eradicated, is exceedingly doubtful. To effect its cure would be to make refined Christians out of brutal sensualists; to emancipate woman from the enticing, alluring slavery of fashion; to uproot false ideas of life and its duties,—in short, to revolutionize society. The crime is perpetrated in secret. Many times no one but the criminal herself is cognizant of the evil deed. Only occasionally do cases come near enough to the surface to be dimly discernible; hence the evident inefficiency of any civil legislation. But the evil is a desperate one, and is increasing; shall no attempt be made to check the tide of crime and save the sufferers from both physical and spiritual perdition? An effort should be made, at least. Let every Christian raise the note of warning. From every Christian pulpit let the truth be spoken in terms too plain for misapprehension. Let those who are known to be guilty of this most revolting crime be looked upon as murderers, as they are; and let their real moral status be distinctly shown.

It should be known, too, that wives are not the only ones to be blamed in this matter. In many instances husbands are the instigators as well as the abettors of the crime, and in their hands lies the power to stay the sacrifices to this horrible modern Moloch.

*J. R. Black, M. D. †Reamy.

Secret Vice.—We most deeply deplore the necessity for mentioning one more evil akin to those already dwelt upon; but our knowledge of the great prevalence and terrible consequences of the awful sin known as solitary or secret vice, masturbation, etc., presses upon us the obligation to let no fit opportunity pass without raising a warning voice. This pernicious habit, which is so common that we need not describe it, we are loth to say, but must in deference to truth, is by no means confined to boys; girls also indulge in it, though, it is to be hoped, to a less fearful extent than boys, at least in this country. A Russian physician, quoted by an eminent medical professor in New York, stated in our hearing that the habit is universal among girls in Russia. It seems impossible that such a statement should be true; and yet we have not seen it contradicted. It is more than probable that the practice is far more nearly universal everywhere than even medical men are willing to admit. Many young men who have been addicted to the vice, have, in their confessions, declared that they found it universal in the schools in which they learned the practice.

Parents who have no suspicion of the evil, who think their children the embodiment of purity, will find by careful observation and inquiry,—though personal testimony cannot be relied upon,—that in numerous instances their supposed virtuous children are old in corruption. Such a revelation has brought dismay into many a family, only too late in some cases. Said a wealthy and intelligent lady in whose hands our work entitled "Plain Facts for Old and Young" was placed by an agent, "Oh, if I had only seen this work ten years ago my poor boy might have been saved!" She was the mother of a large family of sons and daughters, most of whom were remarkably bright and intelligent. But one had fallen a victim to this awful vice, and was then in an insane asylum, his mind a hopeless wreck, in consequence.

The causes of this vice are numerous, including all which tend to produce sexual precocity, and those which have been enumerated as leading to unchastity. These we need not recapitulate; we would, however, mention one cause which in our opinion is, more than all others, the exciting agent in the propagation of the vice; viz.,—

Evil Associations.—The influence of evil companionship is one of the most powerful agents for evil against which those who love purity and are seeking to elevate and benefit their fellow-men have

to contend. A bad boy can do more harm in a community than can be counteracted by all the clergymen, Sabbath-school teachers, tract-distributers, and other Christian workers combined. An evil boy is a pest, compared with which the cholera, small-pox, and even the plague, are nothing. The damage which would be done by a terrific hurricane sweeping with destructive force through a thickly settled district is insignificant compared with the evil work which may be accomplished by one vicious lad.

No community is free from these vipers, these agents of the arch-fiend. Every school, no matter how select it may be, contains a greater or less number of these young moral lepers. Often they pursue their work unsuspected by the good and pure, who do not dream of the vileness pent up in the young brains which have not yet learned the multiplication table, and scarcely learned to read. We have known instances in which a boy of seven or eight years of age has implanted the venom of vice in the hearts and minds of half a score of pure-minded lads within a few days of his first association with them. This vice spreads like wild-fire. It is more "catching" than the most contagious disease, and more tenacious, when once implanted, than the leprosy.

Boys are easily influenced either for right or for wrong, but especially for the wrong; hence it is the duty of parents to select good companions for their children, and it is the duty of children to avoid bad company as they would avoid carrion or the most loathsome object. A boy with a match-box in a powder-magazine would be in no greater danger than in the company of most of the lads who attend our public schools and play upon the streets. It is astonishing how early children, especially boys, will sometimes learn the hideous, shameless tricks of vice which yearly lead thousands down to everlasting death. Often children begin their course of sin while yet cradled in their mother's arms, thus early taught by some vile nurse.

It were better for a boy never to see or associate with a lad of his own age than to run any risk of being corrupted before he is old enough to appreciate the terrible enormity of sin and the awful consequences of transgression. It should be recollected also that not only young boys but vicious youths and young men are frequently the instructors in vice. It is unsafe to trust any but those who are known to be pure. But the difficulties of knowing who is to be trusted are so great that the only real safety is in beginning at a very early age

to fortify the minds of the little ones against the danger by admonitions and instruction suited to their age and understanding.

The Evil Underestimated.—While there have been those who have exaggerated the consequences of secret vice for nefarious purposes there is another class of physicians who take the opposite extreme, declaring that its effects are slight, and often not felt at all. We are at something of a loss to decide which class has done the most harm, the quacks who have basely excited fears beyond what the facts would warrant, for their own selfish advantage, or the medical gentlemen—most of them quite eminent in the profession—who, by declaring the vice to be harmless, have encouraged its propagation. We have no part with either class. The consequences which we have seen in our own experience, having had scores of the victims under our professional care, are sufficiently terrible to warrant us in raising a warning cry which we would gladly make loud enough to reach the ears of every child and youth in America. The vice is an exterminating one. It ruins more lives than all other sexual vices together, because the most prevalent.

We have not space here to dwell at length upon its symptoms and treatment, and need not do so, as we have discussed the subject at length elsewhere.